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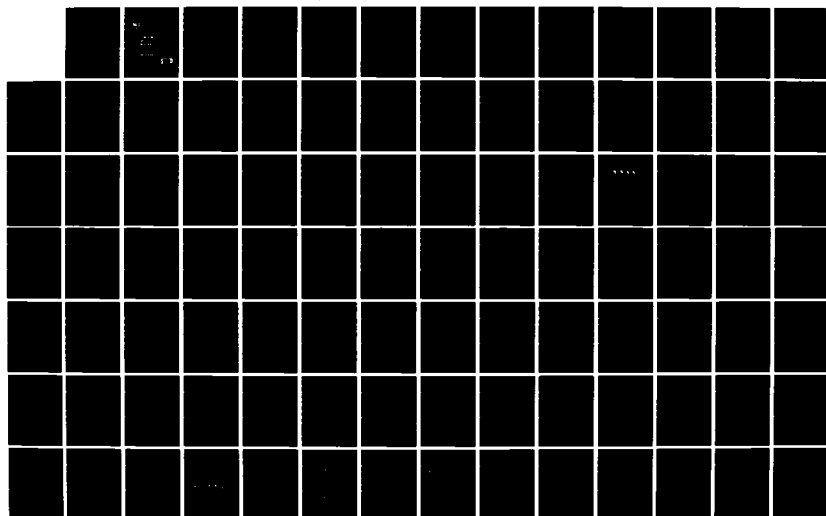
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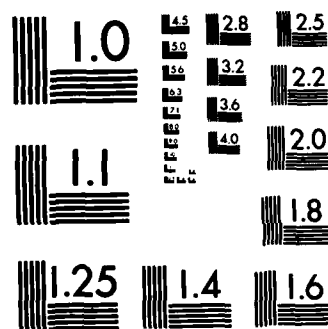
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PETROLEUM FUEL FACILITIES

DESIGN MANUAL 22

DEPARTMENT OF THE NAVY
NAVAL FACILITIES ENGINEERING COMMAND

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20. ABSTRACT (Continue on reverse side if necessary and identify by block number) >Design criteria are presented for use by qualified engineers in designing liquid fueling and dispensing facilities. Included are basic requirements for the design of piping systems, pumps, heaters, and controls; the design of receiving, dispensing, and storage facilities; ballast treatment and sludge removal; corrosion and fire protection; and environmental requirements.		

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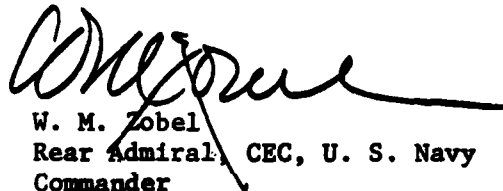
FOREWORD

This design manual is one of a series developed from an evaluation of facilities in the shore establishment, from surveys of the availability of new materials and construction methods, and from selection of the best design practices of NAVFACENGCOM, other Government agencies, and the private sector. This manual uses, to the maximum extent feasible, national professional society, association, and institute standards in accordance with NAVFACENGCOM policy. Deviations from these criteria should not be made without prior approval of NAVFACENGCOM HQ (Code 04).

Design cannot remain static any more than can the naval functions it serves or the technologies it uses. Accordingly, recommendations for improvement are encouraged from within the Navy and from the private sector and should be furnished to NAVFACENGCOM HQ, Code 04.

As the design manuals are revised, they are being restructured. A chapter or a combination of chapters will be issued as a separate design manual for ready reference to specific criteria.

This publication is certified as an official publication of the Command, and has been reviewed and approved in accordance with SECNAVINST 5600.16.



W. M. Zobel
Rear Admiral, CEC, U. S. Navy
Commander
Naval Facilities Engineering Command

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CHAPTER 1. BASIC REQUIREMENTS

Section 1. DESIGN CRITERIA

1. **SCOPE.** These criteria are intended for new construction only. They do not apply retroactively to facilities which existed at the time of issue of this manual. They should, however, be used as a guide for modernization or expansion of existing facilities where such improvements can be justified because of obsolescence, expanded operational requirements, safety, or excessive maintenance costs.

This manual contains general and technical design criteria for naval shore facilities which receive, distribute, or dispense liquid fuel. It is also applicable to the handling of liquified petroleum gases (LPG). Design criteria for LPG facilities are discussed in Chapter 9 of this manual. Policies, obligations, and responsibilities of other commands or offices are referred to only as they affect Naval Facilities Engineering Command (NAVFACENGCOM) projects.

2. **CANCELLATIONS.** This edition of Petroleum Fuel Facilities, NAVFAC DM-22 cancels and supersedes Liquid Fueling and Dispensing Facilities, NAVFAC DM-22 of December, 1972 and Chapter 12 of NAVFAC DM-3, Mechanical Engineering.

3. **RELATED CRITERIA.** For criteria related to petroleum fuel facilities, but appearing elsewhere in military manuals, see the following sources:

<u>Subject</u>	<u>Source</u>
<u>Aircraft Refueling for Shore Activities</u>	NAVAIR 06-5-502
<u>Electrical Engineering</u>	NAVFAC DM-4 Series
<u>Civil Engineering</u>	NAVFAC DM-5 Series
<u>Fire Protection Engineering</u>	NAVFAC DM-8
<u>Harbor and Coastal Facilities</u>	NAVFAC DM-26 Series
<u>Maintenance Manual, Petroleum Fuel Facilities</u>	NAVFAC MO-230
<u>Military Standardization Handbook for Petroleum Operations</u>	MIL-HDBK-201
<u>Oil Spill Pollution Control Manual</u>	NAVFAC P-908
<u>Waterfront Operational Facilities</u>	NAVFAC DM-25 Series

4. **POLICY.** Design of facilities for petroleum fuel shall satisfy operational management requirements of the commands or bureaus having area jurisdiction where the facility is located.

a. **Fuel Specifications.** Federal or Military specifications for the various petroleum fuels to be handled may include the following:

- (1) Federal Specification VV-G-1690, Gasoline Automotive, Leaded or Unleaded.
- (2) Specification MIL-G-3056, Gasoline Automotive, Combat.
- (3) Specification MIL-F-5572, Gasoline, Aviation.
- (4) Specifications MIL-T-5624, 38219, and 83133, Turbine Fuels.

- (5) Federal Specification VV-K-211, Kerosene.
- (6) Federal Specification VV-F-800, Fuel Oil Diesel, Automotive.
- (7) Specification MIL-F-16884, Fuel Oil, Diesel, Marine.
- (8) Specification MIL-F-859, Navy Special Fuel Oil.
- (9) Federal Specification VV-F-815, Fuel Oil, Burner.
- (10) Specification MIL-P-12660, Liquified Petroleum Gas.

5. FUEL PROPERTIES. The following are typical physical properties of various grades of fuel which would affect the design of a petroleum fuel facility:

a. Motor Gasoline (Mogas).

- (1) Density
API Gravity 59° to 65° API
Specific Gravity 0.74 to 0.72
- (2) Reid Vapor Pressure
Summer 7 to 9 psia
Winter 12 to 14 psia
- (3) Flash Point Minus 45° F
- (4) Viscosity at 60° F 1.13 Centistokes (CS)

Special Precautions for Mogas

(a) Because of its high volatility, gasoline produces large amounts of vapor at ordinary temperatures. In one sense, this is good because when confined in a tank or container at liquid temperatures above 20° F, the vapor space is normally too rich to be explosive. At temperatures 20° F or less, vapor spaces above gasoline may be in the explosive range. One gallon of liquid gasoline when vaporized will occupy about 25 cubic feet of space, and if permitted to escape and become diluted with air, it is highly flammable. For this reason, GASOLINE SHOULD NEVER BE CARRIED IN OPEN OR BREAKABLE CONTAINERS AND SHOULD NEVER BE USED FOR CLEANING PURPOSES.

(b) Leaded gasolines contain an anti-knock additive called TETRAETHYL LEAD. The sludge formed in storage tanks which have contained leaded gasoline can be highly toxic to the skin and respiratory system. NEVER ENTER A TANK WHICH HAS CONTAINED LEADED GASOLINE WITHOUT SPECIAL PRECAUTIONS. TANKS OR CONTAINERS WHICH HAVE BEEN USED FOR LEADED GASOLINE STORAGE SHOULD NEVER BE USED TO STORE OR CARRY POTABLE WATER.

(c) Where limitations of lead content of low-lead or no-lead gasolines are enforced, they must be stored in segregated tanks and piping systems which have been cleaned of all lead residues. Double flushing of tanks and piping is usually adequate to accomplish this cleaning.

(d) In designing piping systems for gasoline service, the limiting effects of the vapor pressure on the allowable suction lift and suction piping friction losses must be considered.

b. Aviation Gasoline (Avgas).

- | | | |
|-----|---------------------|----------------------|
| (1) | Density | |
| | API Gravity | 70° API |
| | Specific Gravity | 0.70 |
| (2) | Reid Vapor Pressure | 7 psia (maximum) |
| (3) | Flash Point | Minus 50° F |
| (4) | Viscosity | 1.0 Centistokes (CS) |

Special Precautions for Avgas

(a) The special precautions given for leaded motor gasoline also apply to aviation gasoline.

(b) Because of the critical nature of its use, extra care must be taken to assure that there is no contamination of aviation gasoline by other grades or types of fuels, water, or other foreign substances.

c. Jet Fuels.

- | | | |
|-----|---------------------|-----------------------|
| (1) | Density | |
| | API Gravity | 45° API |
| | Specific Gravity | 0.80 |
| (2) | Reid Vapor Pressure | |
| | JP-4 | 2 to 3 psia |
| | JP-5 | 0 |
| | JP-7 | 0 |
| | JP-8 | 0 |
| (3) | Flash Point | |
| | JP-4 | Minus 20° F |
| | JP-5 | 140° F |
| | JP-7 | 150° F |
| | JP-8 | 100° F |
| (4) | Viscosity at 60° F | |
| | JP-4 | 1.81 Centistokes (CS) |
| | JP-5 | 3.32 CS |
| | JP-7 | 3.64 CS |
| | JP-8 | 2.36 CS |
| (5) | Freeze Point | |
| | JP-4 | Minus 72° F |
| | JP-5 | Minus 51° F |
| | JP-7 | Minus 46° F |
| | JP-8 | Minus 58° F |

Special Precautions for Jet Fuels

(a) Because of the serious consequences of a jet engine failure and also because of the nature of the fuel systems in jet engines, extra care must be exercised to prevent contamination of jet fuels by dirt, water, or other types of fuels. Mixture of grades of jet fuels may be permitted where specifically authorized. Special filtration is required to remove contaminants before the fuel is delivered to aircraft. The use of stainless steel or noncorrosive piping for aircraft fueling systems is required to protect fuel quality. Zinc, copper and zinc or copper bearing alloys shall not be used in contact with aviation fuels from the point of receipt through the final dispensing points including pipe, valves, equipment and accessories. The following are the maximum allowable amounts of contaminants in jet fuels:

	<u>Fuel Receipt</u>	<u>Service to Aircraft</u>
Particulate Matter	10 milligrams per liter	2 milligrams per liter
Free Water	Approx. 30 parts per million	5 parts per million
Appearance	Clear & bright	Clear & bright

(b) Vapor spaces in tanks and containers containing JP-4 are frequently between the upper and lower explosive limits, particularly at temperatures below 60° F. Introduction of a spark or flame can trigger an instantaneous explosion. Therefore, JP-4 must be handled with extra care to avoid the accidental creation of any source of ignition.

d. Kerosene.

- | | | |
|-----|---------------------|--------------------|
| (1) | Density | |
| | API Gravity | 41° API |
| | Specific Gravity | 0.82 |
| (2) | Reid Vapor Pressure | 0.5 psia (maximum) |
| (3) | Flash Point | 110° F (minimum) |
| (4) | Viscosity at 60° F | 2.71 CS |
| (5) | Color | Clear |

Special Precautions for Kerosene

(a) Kerosene is usually handled in separate systems from other distillate products to avoid discoloration.

e. Diesel Fuels.

	<u>Automotive DF-2</u>	<u>Diesel Fuel Marine</u>
(1) Density		
API	35° API	35° API
Specific Gravity	0.84	0.84
(2) Reid Vapor Pressure	0	0
(3) Flash Point	125° F	140° F
(4) Viscosity at 100° F	6.00 CS	10.32 CS
(5) Pour Point	10° F	20° F

Special Precautions for Diesel Fuels

(a) While not as critical as with jet engines, diesel fuel systems are subject to damage by dirt and water in the fuel. Contamination by dirt and water or dilution by lighter fuels should be avoided.

f. Burner Fuel Oils. The physical properties of burner fuel oils are listed in Table 1.

TABLE 1
Typical Properties of Burner Fuel Oils

Grade No.	1	2	3	4	6
API Gravity	41°	37°	22°	17°	15°
Specific Gravity	0.82	0.84	0.92	0.95	0.96
Reid Vapor Pressure	0	0	0	0	0
Minimum Flash Point (°F)	100	100	130	130	150
Viscosity (Centistokes) @ 60° F	2.71	6.00	53.80	108.00 to 323.8	2157.60 to 4315.30
Pour Point (°F)	-10	-5	0	20 to 30	30 to 70
Color	Clear to Straw Color	Straw Color to Amber	Light Brown to Black	Brown to Black	Brown to Black

Special Precautions for Burner Fuel Oils

(a) In nearly all cases #6 fuel oil requires heating to be pumpable. In very cold climates #5 fuel oil may also require heating.

g. Liquified Petroleum Gas (LPG). LPG is odorless, colorless and non-toxic. To reduce the danger of an explosion from undetected leaks, commercial LPG usually contains an odorizing agent which gives it a distinctive pungent odor. LPG is a vapor at atmospheric conditions. It is normally stored as a liquid at a storage pressure exceeding its vapor pressure which is 200 psia.

Special Precautions for LPG

(a) Liquified petroleum gas must be stored under pressure in special pressure resistant tanks.

(b) The fire and explosion potential presents extreme hazards to life and property. Provisions must be made for adequate relief venting and additional fire protection must be supplied in accordance with NFPA 58, STANDARD FOR LIQUIFIED PETROLEUM GASES, STORAGE AND HANDLING.

6. DESIGN FEATURES.

a. Function. Facilities included in this basic category are used to transfer liquid fuels from receiving facilities to storage or issuing facilities. Included are aboveground, underground, and underwater pipelines for transfer and distribution of liquid petroleum fuels, plus all accessory equipment, pump stations, and other equipment and facilities required for a complete system.

b. Design Considerations. Design of petroleum fuel systems shall be complete in all respects as required to meet the operating requirements of the user activity. The complete design may include elements outside of category 125 such as utility buildings, roadways, fuel piers, electric power systems, fire protection systems, etc., as required for a complete facility.

c. Product Segregation. Except as otherwise approved by NAVFACENGCOM Headquarters, petroleum fuel piping systems shall provide separate receiving and distribution piping for the different product grades as follows:

- (1) Motor gasoline (mogas).
- (2) Aviation gasoline (avgas).
- (3) Diesel fuel and distillate type burner fuels (#1, #2 and kerosene).
- (4) Jet fuel, separate systems for each individual grade.
- (5) Residual type burner fuels (#4, #5, and #6).
- (6) Liquified petroleum gas.

Exceptions may be approved in the case of long receiving lines such as from a tanker or barge pier, or a cross country pipeline to a storage facility.

Where such common use is permitted, provisions should be made for receiving and segregating the interface between two grades. The use of spheres or pigs to separate batches should be considered. Exceptions will not be approved for common systems to carry both clean and residual type fuels.

(7) Bottom pumpings. Bottom pumpings shall not be transferred in the petroleum fuel system except bottom pumpings for the purpose of consolidating bottoms which will be cleaned up by a circulating filter such as in operating tanks in an aviation fuel system at air installations.

d. Cross Connections. Provisions should be made to allow the insertion or operation of cross connections between segregated parts of the system. This may be done by one of the following methods:

(1) Removable spool pieces between two valves. Spool pieces shall be removed and blind flanges installed when not in use.

(2) By a double-block-and-bleed arrangement with two valves and a spool piece as described above and a valved bleed connection on the bottom of the spool piece. In normal operating conditions, the main valves are closed and the bleed valve is open to a visible containment system.

(3) The same as (1) or (2) but with visible wedge line blinds in place of the main valves.

(4) Double seal valve with automatic body bleed. The anticipated frequency of operation should be considered in determining which of the above methods to use.

e. Distribution Arrangement. Transfer of fuel should preferably be by pipeline where economically and practically feasible. Projected transfer volumes, distance, terrain, operating cost, and reliability of supply should be considered in determining feasibility.

Where the use of a pipeline cannot be justified, other methods of transfer that should be considered include the use of tankers or barges, (if piers are not available, the use of offshore moorings and underwater pipelines should be considered) or where the use of water transportation is not practical, transfer by tank truck or tank car may be a viable option.

f. Piping. Aboveground piping is preferred in areas where it is not aesthetically objectionable or not exposed to accidental damage, vandalism, blast damage, or sabotage. Piping on fuel piers should be above the pier deck. All aboveground and above deck piping should have protection against accidental damage by vehicles, vessels, or other moving or falling objects. Aboveground piping should rest on adequate supports and be entirely clear of the ground. All aboveground or above deck piping should be completely accessible for testing, inspection, and maintenance painting.

All underground and underwater piping should have an exterior protective coating and also be protected against exterior corrosion by a cathodic protection system. Underground piping should be buried at sufficient depth to prevent damage from surface loads. The underground use of flanges, valves, or similar fittings which might be subject to leaks should be avoided.

g. Transfer Flow Rates. Minimum design flow rates shall be in accordance with Table 2. In some cases, greater rates may be needed to meet the operational requirements of a particular facility.

TABLE 2
Fuel Transfer Flow Rates

Service ¹	Diesel Fuel	Jet Fuel	Burner Fuel Oils	Avgas and Mogas
Between super tanker and storage (bph)	24,000	24,000	24,000	24,000
Between regular tanker and storage (bph)	8,000	8,000	8,000	8,000
Between barge and storage (bph)	2,500	2,500	2,500	2,500
To fleet oilers (bph)	5,000	5,000	3,000	3,000
To AOE's	10,000	10,000	3,000	3,000
To carrier (bph)	3,500	3,500	-----	2,500
To average cruisers (bph)	2,000	1,000	-----	-----
To average destroyer (bph)	2,000	1,000	-----	-----
Between storage tanks (gpm)	600	600	600	600
	to	to	to	to
	10,000	10,000	1,200	1,200
Tank car unloading to storage (gpm per car)	300	300	300	300
Tank truck unloading to storage (gpm per truck)	300	300	300	300
Storage to tank car loading (gpm per car)	600	600	300	300
			to	to
			600	600
Storage to tank truck loading (gpm per loading arm or bottom loading hose)	300	300	300	300
	to	to	to	to
	600	600	600	600
Delivery from direct fueling stations to aircraft (gpm)	-----	600	-----	
Delivery from refueler truck to aircraft (gpm)	-----	300	-----	

¹At dockside, deliveries from tankers should be assumed to be at a pressure of 80 to 100 psig, and deliveries to tankers to be at 60 psig. Rates to other ships are maximums based on fueling at sea capacities. Lesser rates for fueling at piers can be used if more practicable. Loading rates are based on 40 psig minimum at ship connections.

h. Protection Against Damage. Fuel facilities shall be planned and designed with a view toward protection of fuels, storage, and transfer capability from enemy attack, sabotage, fire, and other damaging influences.

(1) Degree of Protection. The specified degree of blast and damage resistance capability will vary with geographical locations, site conditions, missions, and strategic importance of activities.

(2) Design Criteria. In general, the design of fuel facilities shall be consistent with prescribed criteria, and in accordance with those contained in appropriate classified directives and instructions.

i. Operation Capability. A design shall also include a basis for continued operation of a facility by emergency or temporary expedients, and it shall be continuous despite the loss of one or more components by enemy action or by another reason. Facilities shall have an alternate source of fuel supply to assure a continuance of operation under the most adverse conditions.

j. Construction. A design should be amenable to rapid construction.

k. Fire Protection. Fire protection shall be provided in all fuel facility areas in accordance with Chapter 7.

l. Protection Against Hazards. The design shall be directed toward minimizing hazards associated with specific fuels handled at a facility. The major hazards are fire and explosion. Specific design features to be considered in the reduction of hazards are as follows:

(1) Electrical Installations. All fuel facilities, except as modified by this Guide, shall be classified in accordance with API RP 500A, Recommended Practice for Classification of Areas for Electrical Installations in Petroleum Refineries Plants, NFPA 30, Flammable and Combustible Liquids Code, and NFPA 70, National Electric Code. Modifications to these practices may be required where unusual conditions occur, where locations contain hazardous atmospheres classified other than Group D, or where equipment malfunction may cause hazardous situations. Sound judgment should be used in applying these requirements and specifications of higher classification and should be used wherever necessary to maintain safety and continuity of service. Class I, Division 1 locations include:

(a) Inadequately ventilated indoor locations containing pumps, bleeders, withdrawal fittings, meters, and similar devices that are located in pipelines handling flammable and combustible liquids under pressure.

(b) All outdoor locations and those indoor locations having positive and mechanical ventilation that are in the immediate vicinity of the fill openings or vents on individual containers to which flammable liquids are being transferred (as defined in NFPA 30 and NFPA 70). Alarm devices shall be provided on all ventilation systems.

(c) Outdoor locations in the immediate vicinity of vents and openings on individual containers, storage tanks, and vehicles where flammable liquids are handled (as defined in NFPA 30 and NFPA 70).

(d) Inadequately ventilated indoor locations that do not contain a source of hazard but are located within a Division 2 location.

(e) Pits, pumps, open trenches, and other depressions, any part of which are within a Division 2 location and are not provided with positive and reliable mechanical ventilation.

(f) Locations within and on exterior walls of API separators.

(g) Locations on petroleum piers and wharves.

(h) Locations at fuel dispensers (as defined in NFPA 30 and NFPA 70).

Class I, Division 2 locations include:

(a) Adequately ventilated indoor locations containing pumps, bleeders, withdrawal fittings, meters, and similar devices that are located in pipelines handling flammable and combustible liquids under pressure that are within 5 foot distance extending in all directions from the exterior surface of such devices. The Class I, Division 2 location shall also extend 25 feet horizontally from any surface of the devices and extend upward 3 feet above floor or grade level. Ventilation system shall have alarm devices.

(b) All outdoor locations and those indoor locations having positive and mechanical ventilation that are adjacent to Division 1 zones at fill openings and vents on individual containers to which flammable and combustible liquids are being transferred (as defined in NFPA 30 and NFPA 70).

(c) Outdoor locations that are adjacent to the Division 1 zones at vents and openings on individual containers, storage tanks, and vehicles where flammable or combustible liquids are handled (as defined in NFPA 30 and NFPA 70).

(d) Pits, sumps, open trenches, and other depressions any part of which are within a Division 2 location and are provided with positive and reliable mechanical ventilation.

(e) Outdoor locations within 3 feet of the exterior surface of pumps, bleeders, withdrawal fittings, meters, and similar devices that are located in pipelines handling flammable or combustible liquids under pressure. The Class I, Division 2, location shall also extend upward 18 inches above grade level within 10 feet horizontally from any surface of the device.

(f) Locations within and extending upward to the top of dikes that surround aboveground tanks containing flammable or combustible liquids.

(g) Locations extending upward 18 inches above grade level within 50 feet horizontally from any surface API separators.

(h) Storage and repair garages for tank vehicles up to 18 inches above floor or grade level.

Nonclassified locations include:

(a) Outdoor locations having closed piping systems handling volatile flammable or combustible liquids that have no valves, screwed fittings, flanges, meters, or similar devices which create joints in piping.

(b) Office buildings, boiler rooms, and similar locations that are outside the limits of hazardous locations as defined above and are not used for handling or storage of flammable or combustible liquids or containers for such liquids.

(2) Equipment. Equipment layout, clearances, and design of a complete installation shall conform to API Bulletin RP-540, Recommended Practice for Electrical Installations in Petroleum Processing Plants, NFPA 70, National Electric Code, NFPA 77, Static Electricity, and NFPA 78, Lightning Protection Code.

(3) Static Electricity Generation. Precautions shall be taken in design to minimize specific hazards associated with static electricity generation. See Section 6 of this Chapter NAVFAC MO-230, Maintenance Manual, Petroleum Fuel Facilities and API RP 2003, Protection Against Ignition Arising Out of Static, Lightning and Stray Currents.

m. Illumination. Unless otherwise directed by NAVFACENGCOM HQ, all working areas shall be illuminated for night operations to the minimum intensity recommended in Table 3 of API Bulletin RP-540, Recommended Practice for Electrical Installations in Petroleum Processing Plants. Facilities which come under the jurisdiction of the U.S. Coast Guard under 33 CFR, Chapter 1, Subchapter O, shall be illuminated with a minimum intensity required by that regulation.

n. Grounding and Bonding. The following references shall apply for grounding and bonding systems for fault current protection, lightning protection, and prevention of static electricity.

American National Standards Institute (ANSI) Standard 142, Recommended Practice for Grounding Industrial and Commercial Power Systems.

NFPA Standards 70, 77 and 78.

API RP-540.

API Bulletin 1003, Precautions Against Ignition During Loading of Tank Truck Motor Vehicles.

API RP-2003.

The following items shall be grounded directly through ground rods or beds or bonded to a grounded network:

- (1) Motor, generator, and transformer frames.
- (2) Noncurrent-carrying metallic parts of electrical equipment and installations, such as enclosures for panelboards, switchgear, motor control centers, and substation fences.
- (3) Lightning arresters and lightning shield conductors.
- (4) Metallic messengers of self-supporting cables.
- (5) Tanks, vessels, stacks, exchangers, and similar equipment not directly supported or bolted to a grounded supporting structure.

(6) Operating mechanisms of overhead airbreak switches.

(7) Exposed conductive materials enclosing electrical conductors, such as metallic conduit, electrical metallic tubing, metallic tubing, metallic armoring, sheaths, and shields; cable troughs, trays, and racks, wireways, and busways.

(8) Pipe support columns at intervals normally not exceeding 75 feet.

(9) Aircraft direct fueling stations.

(10) Aboveground storage tanks. Floating pans in storage tanks shall be bonded to the tank shells as described in Chapter 4, Section 3, paragraph 4. Floating roofs in open top storage tanks shall also be bonded to the tank shell. Grounding systems for instrumentation, instrument control boards, and electronic equipment shall be isolated from all other ground systems. Overhead electrical equipment bolted directly to grounded metallic structures shall not require additional grounding. The conductor connecting a lightning rod to the grounding electrode shall be separate from other grounding conductors where feasible and shall be routed with a minimum of sharp bends and in the most direct manner to the grounding electrode. This electrode shall not be used in lieu of made grounding electrodes which may be required for other systems. This provision shall not prohibit the required bonding together for grounding electrodes of different systems.

o. Electromagnetic Radiation. Provide clearance from equipment capable of emitting electromagnetic radiation as described in Section 7 of this Chapter.

p. Communications. Provide telephone communications between separated areas such as receiving, dispensing, pump stations, and storage to coordinate operations involved in fuel transfer. (See NAVFAC DM-4, Electrical Engineering.)

q. Clearances. Clear distances between petroleum fuel facilities and occupied buildings, property lines, public roads and component parts of the petroleum fuel facility shall be as described in Chapter 4, Section 1.

r. Protection of the Environment. The design shall comply with all Federal and local laws pertaining to the protection of the environment including the air, water and land.

s. Occupational Safety and Health Act. Designs for facilities within the continental United States and affected territories and possessions shall comply with the Occupational Safety and Health Act 29 CFR Part 1910.

t. Corrosion Protection. The design of underground piping systems shall include protection against underground corrosion by a combination of coatings and cathodic protection as described in Chapter 6.

u. Security. Provide security fencing around all petroleum facilities to insure safety and prevent sabotage, theft, vandalism or entry by unauthorized persons. The fence shall be 7 feet high chain link type with an

additional three-strand barbed wire outrigger on top or its equivalent. Suitable gates and padlocks shall be provided. Fencing shall be in accordance with NAVFAC DM 5.12, Fences, Gates and Guard Towers.

Section 2. PIPING SYSTEMS

1. DESIGN REQUIREMENTS.

a. General Requirements. Piping design, materials, fabrication, assembly, erection, inspection, and pressure tests or intraterminal piping systems shall be in accordance with ANSI Standard B31.3, Petroleum Refinery Piping. Piping design or interterminal pipelines shall be in accordance with ANSI Standard B31.4, Liquid Petroleum Transportation Piping Systems.

Inspection shall include radiographic or magnetic particle inspection of welds where applicable. (See API Standard 1104, Standard for Welding Pipelines and Related Facilities.)

New piping systems shall be hydrostatically tested in accordance with API RP 1110, Recommended Practice for Pressure Testing of Liquid Petroleum Pipelines. Testing of interterminal pipelines shall also comply with the requirements of CFR 49, Part 195, Subpart E, Paragraph 195.00. During testing, system components such as storage tanks, filter/separators, or similar equipment which were not designed for the piping test pressure shall be disconnected and protected against damage by over-pressure.

b. Hydraulic Design. Pipe sizes shall be carefully selected with consideration to the following factors:

- (1) Operating requirements of the facility to be served.
- (2) Capital cost of the pipe.
- (3) Capital cost of pumping stations and attendant facilities.
- (4) Operating cost of the system.
- (5) Harmful effects of excessive velocity of flow including hydraulic shock and static generation.

In general, consideration of these factors will result in a design with a velocity of 7 to 12 feet per second at full flow.

Piping design for #5 and #6 burner fuel oils shall also give consideration to the effect of fuel temperature on viscosity and hence on pumpability. This is illustrated in Figure 1. In general, it is usually desirable to heat #6 fuel oil into the range of 120° F to 130° F for pumping. In many cold climates, #5 fuel oil and lubricating oil may also require heating. Other products do not require heating.

Friction losses caused by the flow of liquid through the piping and connected equipment and fittings should be calculated by the Fanning formula. Tabulated values for liquids of various viscosities flowing through different sized pipe can be found in Ingersoll-Rand's, Cameron Hydraulic Data. Similar information can be found in chart form on Figure 2 in this manual.

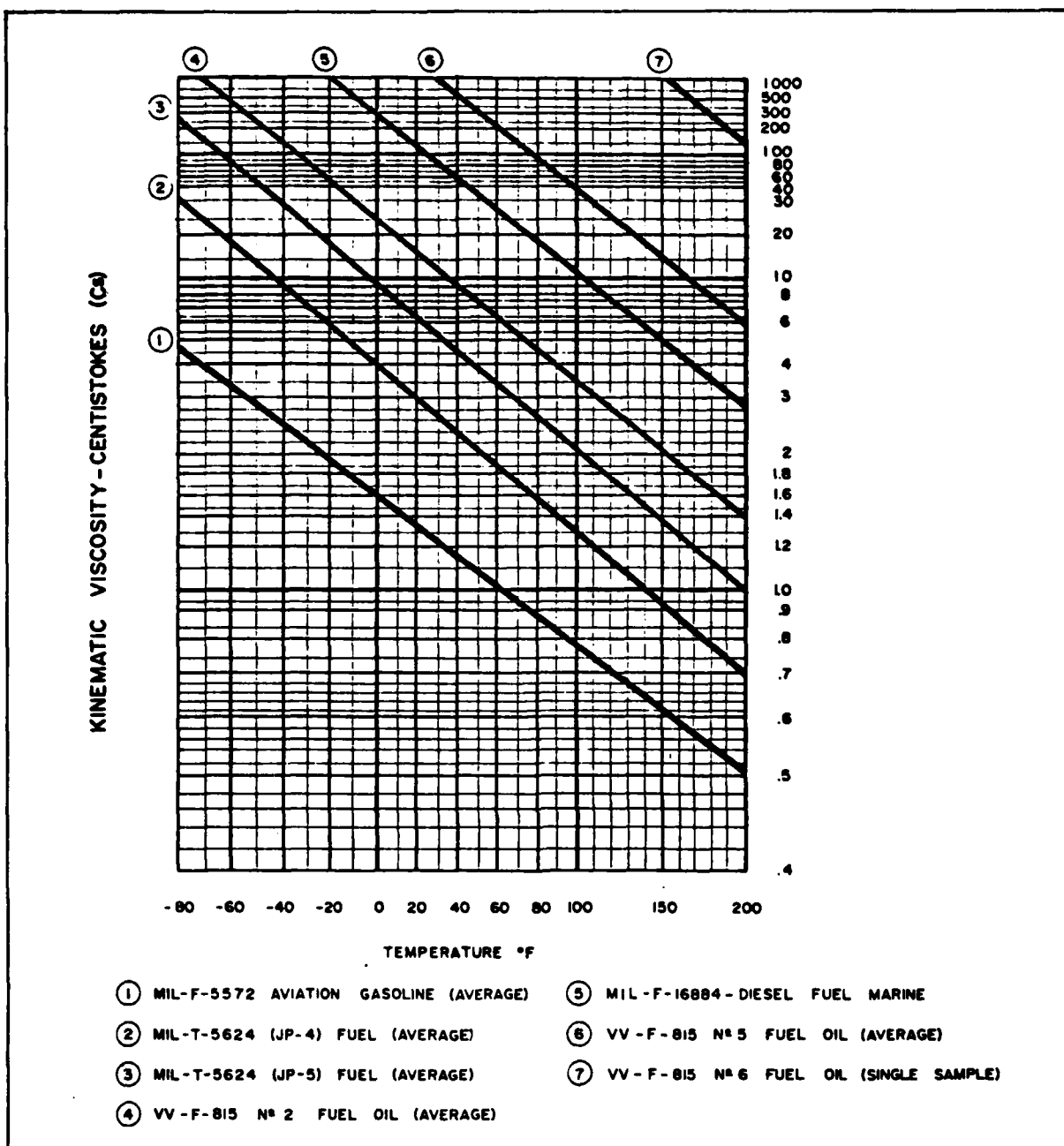


FIGURE 1
Petroleum Fuels
Viscosity Vs. Temperature

Suction piping shall be carefully designed to ensure that the net positive suction head required by the pumps is available under all conditions of operation.

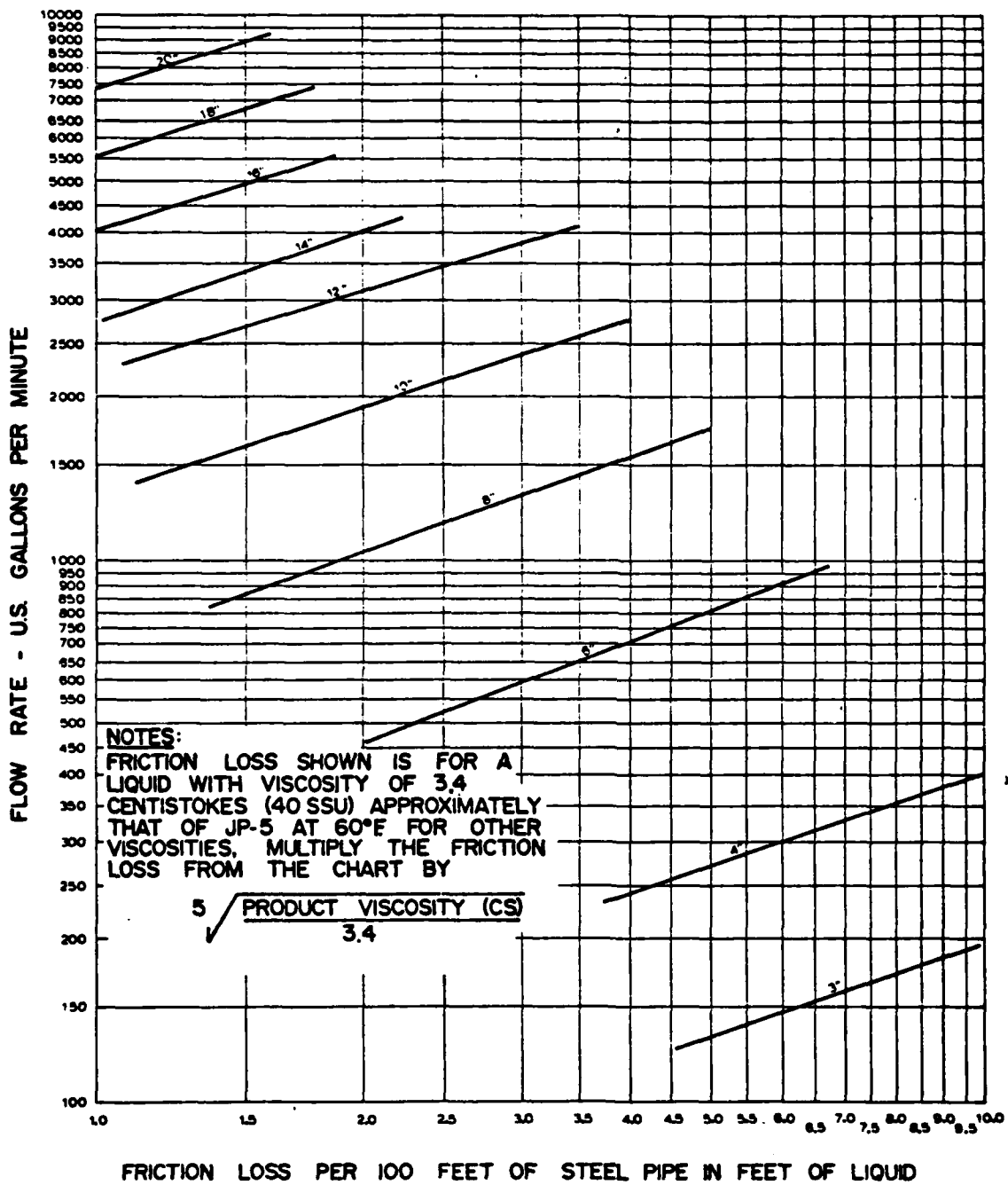


FIGURE 2
 Pipe Flow Chart

The hydraulic design shall give full consideration to the causes and effects of hydraulic shock. This is especially important in closed fueling systems such as aircraft fueling systems where the receiving tanks may be damaged by shock pressure. Shock arresters should only be used as a last resort. It is preferable that the possibility of shock be reduced by limiting the velocity of flow and avoiding the use of quick closing valves.

c. Piping Arrangement. Wherever possible, arrange piping in parallel groups to facilitate multiple use of supports, to minimize the amount of trenching for underground piping, and to provide maximum freedom of access across pipe runs. Table 3 shows the recommended center-to-center distance between pipes of various sizes.

The use of looped piping systems should be provided whenever practical. Loops add to the flexibility and reliability of the system. They contribute to product cleanliness by making circulation possible. They can also be used to reduce the possibility of hydraulic shock. Loops should be sectionalized by block valves.

Between mains, cross connections can be installed for flexibility of operation and as auxiliary means of continuous operation in case of enemy damage, as described in Section 1, paragraph 6 of this Chapter. In addition, where space limitations preclude the use of removable pipe sections or fittings, or where connections are made to multiproduct pipelines, the use of line blinds with manually operated block valves on either side of twin seal valves with valved bleed connection shall be permitted.

For short runs, line slope shall be 2 inches per 100 feet of length. For long runs, line slope shall be necessary to establish positive drain by gravity, but without excessive bury depth. Gradients shall be uniform between high and low points. Traps or low points are undesirable because they provide a place for water and sediment to accumulate. Where they cannot be avoided, drains shall be installed at low points to allow removal of any water and sediment.

The piping arrangement shall provide for the effect of expansion and contraction of the pipe caused by changes in ambient temperature or artificial temperature changes in heated fuel piping. Where possible, expansion and contraction should be accommodated by changes in direction in piping runs, offsets, loops, or bends. Where this method is not practical, flexible ball joint offsets, or bellows type joints should be used. Alignment guides shall be provided on each side of the expansion joint. Expansion devices which employ packings, slip joints, friction fits, or other nonfire resistant arrangements shall not be used. Ball type offset joints may also be used to accommodate possible settlement of heavy structures such as storage tanks. Expansion bends, loops, and offsets shall be designed within stress limitations in accordance with ANSI B31.3 or B31.4 as appropriate. (See Piping Handbook, by Crocker and King for design methods.)

TABLE 3
Minimum Center-to-Center Spacing For Steel Pipe
Welded Steel Pipe With Class 150 ANSI Flanges

Pipe Size		Flange O.D.		Spacing	Pipe Size		Flange O.D.		Spacing
A	B	A	B	(Inches)	A	B	A	B	(Inches)
18	18	25	25	27	10	10	16	16	18
18	16	25	23.5	26.25	10	8	16	13.5	16.75
18	14	25	21	25	10	6	16	11	15.5
18	12	25	19	24	10	4	16	9	14.5
18	10	25	16	22.5	8	8	13.5	13.5	15.5
18	8	25	13.5	21.25	8	6	13.5	11	14.25
18	6	25	11	20	8	4	13.5	9	13.25
18	4	25	9	10	6	6	11	11	13
16	16	23.5	23.5	25.5	6	4	11	9	12
16	14	23.5	21	24.5	4	4	9	9	11
16	12	23.5	19	23.25		3		7.5	10.25
16	10	23.5	16	21.75	3	3	7.5	7.5	9.5
16	8	23.5	13.5	20.5					
16	6	23.5	11	19.25					
16	4	23.5	9	18.25					
14	14	21	21	23					
14	12	21	19	22					
14	10	21	16	20.5					
14	8	21	13.55	19.25					
14	6	21	11	18					
14	4	21	9	17					
12	12	19	19	21					
12	10	19	16	19.5					
12	8	19	13.55	18.25					
12	6	19	11	17					

Anchor aboveground piping at key points so expansion will occur in the desired direction. Anchors should be spaced to provide maximum straight runs of piping from expansion points to the anchors. In general, anchors should also be placed at all points of the system where only a minimum of piping movement can be tolerated, such as at branch connections and equipment connections. Key locations should include pump houses or other buildings, manifolds, at changes of direction where such directional change is not used as an expansion joint, points in the line at which the pipe size is drastically reduced related to adjacent piping, and at all terminal points. The excessive use of anchors is not desirable and should be limited to the situations described above.

The design shall also provide for relief of excessive pressures that may be caused by thermal expansion of the liquid in the pipe between shutoff points. The coefficient of expansion of liquid petroleum in the range of 35° - 59.9° API at 60° F is .0005 per degree Fahrenheit. Provide line

valves with relief valve bypasses to relieve increased pressures caused by solar or other heating of static fluids in closed-off stretches of piping and equipment. On remotely controlled valves, located where excessive bonnet pressure can develop when in the closed position, provide relief valves on the bonnets. Relief valves should never discharge to grade, or to the storm water drainage system. A relief valve should ideally discharge directly into a storage or holding tank at atmospheric pressure (or at other normal storage pressure, as in the case of liquified petroleum gas). Alternatively, any relief valve may be connected to discharge to tankage through one or more successive adjacent stretches of piping. Each relief valve shall be similarly protected, provided that the relief valve setting in each downstream stretch is lower than that of any relief valve or valves that discharge into it, and provided that all stretches contain the same product. For any isolated stretch of piping on which the relief valve discharge cannot be connected as described above, provide a vented sump tank of suitable capacity which is equipped to be emptied by means of a portable pump. Valves for relief of thermal expansion shall be not less than 3/4-inch nominal pipe size. They shall be set to open at a pressure approximately 10 percent above the operating pressure of the line. Relief valves for thermal expansion shall have a rising stem gate valve with handle removed on both inlet and outlet sides.

Aboveground piping shall be supported on pipe supports designed and constructed in accordance with good structural practice. Minimum spacing of pipe supports shall be in accordance with Table 4. The supported pipes shall be entirely clear of the ground. The portion of pipe supports in contact with the ground shall be constructed of, or covered with, concrete for a minimum distance of 6 inches above the surface of the ground. Figure 3 shows a typical pipe support arrangement. The interface between the pipe support shoe and the pipe support shall be smooth and free to move with the thermal expansion.

Underground piping which passes under public roadways or railroad shall be in accordance with API RP-1102, Recommended Practice for Liquid Petroleum Pipelines Crossing Railroads and Highways and with Department of Transportation regulations. Provide casings only where required by local government regulations. If used, casings shall be equipped with seals, vents and insulators. Fill the space between the carrier pipe and the casing with a fuel resistant plastic material that will remain pliable and prevent the entrance of water.

Interterminal pipelines shall be equipped with facilities for launching and recovering scrapers, pigs, or balls. The design should be capable of accommodating instrument pigs for internal inspection of the pipe. Similar arrangements should be considered for long lines, over 1 mile in length, within bulk terminals. They are not considered necessary for aircraft fueling systems.

2. PIPE, VALVES, AND FITTINGS

a. Pipe Material. Piping material for all fuel systems, except aviation fueling systems, shall be carbon steel, American Society for Testing Materials (ASTM) Standard A-53, Grade B or API 5L, Grade B. Pressure temperature ratings of all piping valves and fittings shall conform to ANSI B31.33 or B31.4 as appropriate.

TABLE 4
Pipe Support Spacing
Welded Steel Pipe ASTM A53, Grade B
Maximum Temperature 150° F
No Insulation

Pipe Size	Sched. or Weight	Support Spacing (Feet)	
		Continuous Spans	End Spans
1/2"	80 (XS)	8	5
3/4"	80 (XS)	10	7
1"	80 (XS)	13	9
1-1/2"	80 (XS)	18	12
2"	80 (XS)	21	14
2-1/2"	40 (STD)	21	14
	80 (XS)	25	17
3"	40 (STD)	23	17
4"	40 (STD)	27	20
6"	40 (STD)	32	26
8"	30	37	30
	40 (STD)	40	32
10"	30	40	33
	40 (STD)	43	35
12"	30	43	35
	(STD)	46	38
14"	20	43	35
	30 (STD)	48	39
16"	20	43	37
	30 (STD)	48	39
18"	20	35	37
	(STD)	51	41
20"	20 (STD)	49	41

Piping material for new systems used for fueling aircraft or for loading aircraft refuelers with avgas or jet fuel shall be of stainless steel in accordance with ASTM A-312, Grade 304L, aluminum in accordance with ASTM B-241, Alloy No. 5083, Temper H112, or Alloy No. 6061, Temper T-6, or glass fiber reinforced plastic (FRP) in accordance with MIL-V-29206 from the tank outlet to the last fuel discharge point including any return or circulating lines back to the storage tanks or filter/separators. FRP shall not be used above-ground. Carbon steel piping may be used for extensions of existing carbon steel systems on the upstream side of the final filter/separator.

Piping material for ballast unloading systems shall be carbon steel pipe with a corrosion resistant internal lining.

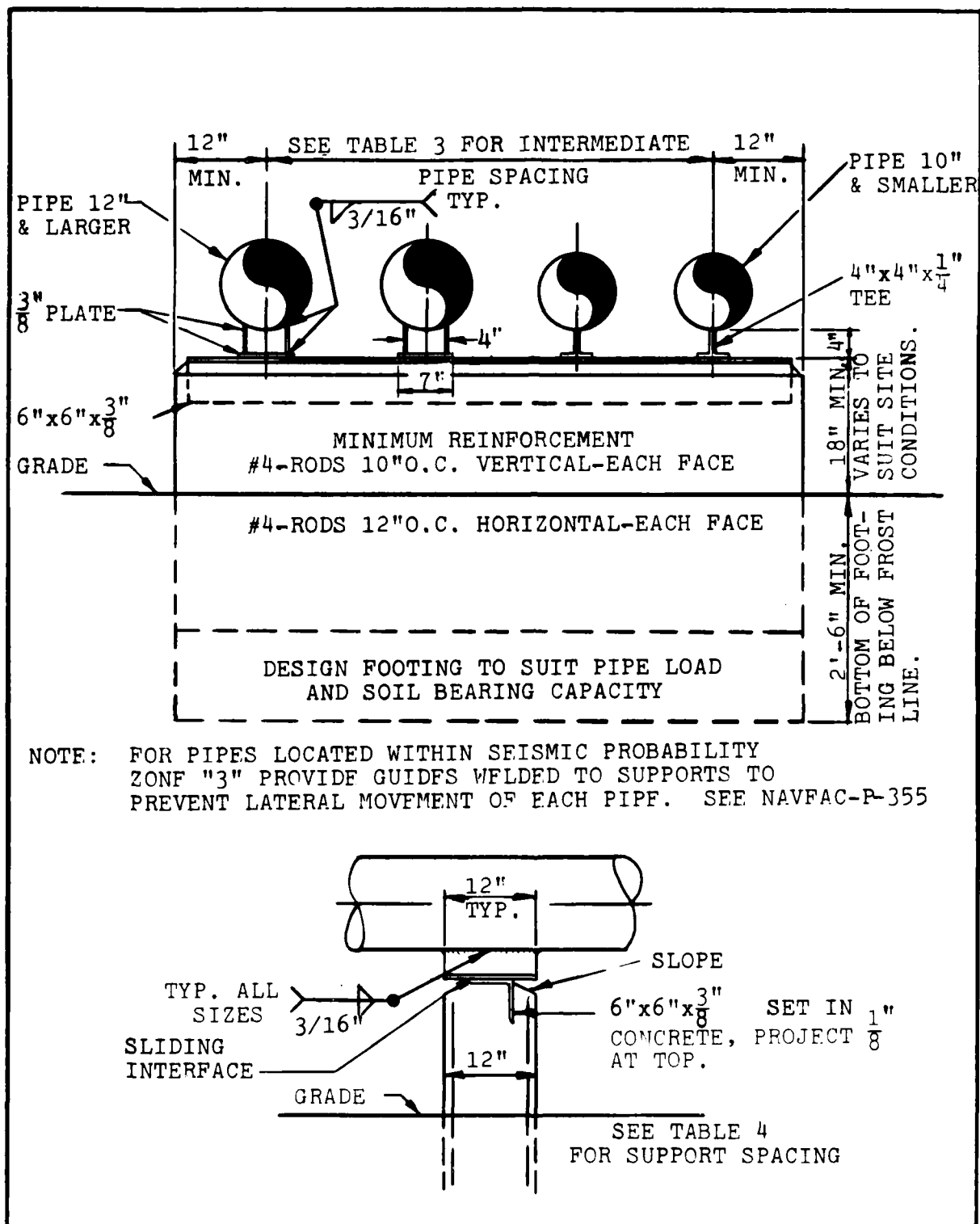


FIGURE 3
Typical Pipe Support

b. Valves.

(1) Valve locations. Valves shall be provided in product piping systems to control flow and to permit isolation of equipment for maintenance and repair. These valves will be manually operated, except where motor operators are specifically authorized by applicable standard drawings or technical specifications. As a minimum requirement, block valves shall be provided at the following locations:

(a) On the aboveground piping at each tank car, tank truck, barge, or tanker unloading connection. This requirement will not apply to gravity unloading lines unless block valves are specifically called for on applicable drawings.

(b) On the aboveground piping at each tank car, tank truck, barge, or tanker loading connection.

(c) On the upstream and downstream side of each line blind at connections to cross country pipelines.

(d) At all subsurface and aboveground piping connections to storage tanks.

(e) On each branch line at the point of connection to the main product pipeline or header.

(f) On the main product pipeline or header just before the line leaves a pumping station.

(g) At the shore end of piping on piers.

(h) On each main distribution pipeline immediately downstream of the branch connection to each existing or future operating storage facility served by the pipeline.

(i) At intermediate points of approximately 10 miles in cross country distribution pipelines to facilitate isolation of a section of the line for maintenance and repair.

(j) On each side of water crossing, and near the shoreline of a submerged sea pipeline.

(k) On the suction side and discharge side of each pumping unit, except the suction side of vertical centrifugal pumps installed in underground tanks.

(l) On discharge side of pumps where backflow is possible, provide a check valve.

(m) At all aircraft direct fueling connections.

(n) On the inlet and outlet connection of each line strainer, filter/separator, meter, automatic valve, and other equipment that

requires periodic servicing. One inlet valve and one outlet valve may be used to isolate more than one piece of adjacent equipment which are connected in series.

(o) All other locations as shown on the definitive drawings for specific types of applications.

(2) Valve Materials. All valves in noncorrosive aviation fuel systems shall have aluminum or stainless steel bodies and shall not have zinc, zinc coated, copper, or copper bearing materials in contact with the fuel.

All other valves shall have carbon steel bodies and bonnets. Cast iron or bronze bodied valves shall not be furnished or installed in liquid petroleum service.

(3) Types of Valves.

(a) Gate valves may be used for shutoff service where a slow closure is acceptable and where absolute bubble-tight closure is not a critical consideration. Gate valves shall be rising stem, outside stem and yoke, double disk type. Gate valves shall be in accordance with the API Standard 6D, Specification for Pipeline Valves and applicable performance requirements of MIL-V-12003, Valve, Plug, Cast Iron or Steel.

(b) Ball, butterfly or nonlubricated plug valves are preferred for jet fuel and avgas services, or where quick or frequent opening or closing is required. Synthetic seals or seating material in ball and butterfly valves shall be teflon or viton. The valve shall be designed so that, if the synthetic seating material were burned out in a fire exposure, there will still be a metal to metal seat to effect closure.

Ball valves shall conform to the requirements of WW-V-35, Valve, Ball or for valves larger than 12 inches to API 6D, Pipeline Valves.

Butterfly valves shall be high performance type with eccentric disc shaft and camming action for bubble-tight shutoff.

Plug valves shall conform to the requirements of MIL-V-12003, Valve, Plug, Cast Iron or Steel.

Lubricated plug valves shall not be used.

(c) Double seated plug or ball valves with an automatic body bleed between the seats should be used for separation of product services, on tank shell connections, and other locations critical to pressure testing of piping.

(d) Check valves shall be used to prevent backflow through pumps, branch lines, meters or other locations where runback or reverse flow must be avoided. Check valves may be of the swing disk, spring loaded poppet, ball, or diaphragm actuated types. Swing checks shall be soft seated nonslamming type with renewable seats and disks. Check valves shall conform to API Standard 6D.

(e) Globe valves shall be used only where there is a frequent requirement for throttling. The use of globe valves should be avoided because of their high resistance to flow. Globe valves shall conform to the requirements of MIL-V-18434, Valves, Gate, Globe and Angle.

(f) Diaphragm type valves which operate on a pressure differential in the system are recommended for automatic or remote control functions such as water slug shutoff, flow control, pressure control, or level control. Diaphragm valves with carbon steel bodies shall have steel pilot valves and tubing. Diaphragm valves with stainless steel or aluminum bodies shall have stainless steel pilots and tubing. All valves shall have teflon or viton packings, seals, and trim.

(4) Valve Operators. Valves not specified for remote, automatic, or emergency operation shall be manually operated. Gate valves larger than 12 inches shall have geared operators. Ball and plug valves larger than 6 inches shall have geared operators.

Gate, ball, and plug valves specified for remote, automatic, or emergency service may have electric motor operators with suitable torque limiting controls. Diaphragm valves specified for remote operation may have solenoid pilot controls. All electrical apparatus shall be in enclosures suitable for the classification of the area in which they are to be used.

c. Flanges and Fittings. Flanges for carbon steel piping systems shall be weld neck forged or rolled steel in accordance with ASTM A-181, Carbon Steel Flanges, Fittings and Valves, Grade I with 1/16-inch raised faces. Dimensional standards shall be in accordance with ANSI B16.5, Steel Pipe Flanges and Flanged Fittings. Raised faces shall have a modified spiral serrated gasket surface finish. Cast iron flanges shall not be used. Victaulic couplings or similar fittings shall not be used in permanent fixed piping systems. Flanges shall not be direct buried.

Fittings for carbon steel piping systems shall be butt welding, seamless, forged steel in accordance with ASTM A-234, Carbon Steel Seamless and Welded Fittings, Type WPB.

Threaded joints may be used in carbon steel piping systems 2 inch nominal size and smaller. Threaded joints shall not be used in aluminum piping systems. Glass fiber reinforced plastic (FRP) piping shall be joined by bell and spigot joints sealed with adhesive except that FRP flanges may be used for connections to flanged equipment such as pumps or valves. Fittings for threaded pipe shall be 3,000 pound forged steel.

Fittings for stainless steel piping systems shall be ASTM A-403, Wrought Austenitic Stainless Steel Piping Fittings, Grade WP 304, flanges ASTM A-182, Forged or Rolled Alloy Steel Pipe Flanges, Grade F 304. Fittings and flanges for aluminum piping shall be of the same material as the pipe.

Make branch connections with butt welding tees except where the branch is at least two pipe sizes smaller than the run, in which case the branch connection can be made with a forged or seamless factory fitted branch connection.

Wrinkle bends or miter bends shall not be used for changes in direction.

d. Welding. All welds shall conform to ANSI Standard B31.3 or B31.4 as appropriate.

e. Bolts, Nuts, and Gaskets. For temperatures up to 400° F, flange bolts for carbon steel flanges should be carbon steel machine bolts in accordance with ASTM A-307, Grade B, with cold pressed hexagonal nuts in accordance with ASTM A-194, Grade 8, and steel washers. For operating temperatures 400° F or more, or operating pressures above 300 psi, high tensile stud bolts conforming to ASTM A-193, Grade B8, should be used.

Stainless steel bolts and nuts shall be used for all noncorrosive flanges regardless of material. Stainless steel flange bolts and nuts shall be used for carbon steel pipe on piers or underwater.

Gaskets for temperatures not over 200° F should be cut ring gaskets of composition asbestos 1/16-inch thick. For temperatures of 200° F or more, use spiral wound steel asbestos gaskets.

f. Fuel Hose. Hose needed to make connections between the transfer piping and tank cars, trucks, and vessels for receiving and issuing fuel shall conform to the appropriate Military Specification. Sizes shall be as required for design flow rates. Hose flanges and nipples shall be of carbon steel, except that for hoses at aviation fuel issue points where all metal parts contacting the fuel shall be of stainless steel or aluminum.

3. ACCESSORIES.

a. Meters. Install fuel meters at points of fuel issue or custody transfer within a new facility. Examples of such points are:

- (1) Tank truck or refueler fill stands.
- (2) Tank car loading stands.
- (3) Aircraft direct fueling stations.
- (4) Motor vehicle fueling dispensers.
- (5) Ship or boat fueling connections.
- (6) Tanker or barge loading connections.
- (7) Pipeline shipping connections.

Consideration shall be given to the use of temperature compensated meters at custody transfer points.

Meters used for service such as fueling aircraft, motor vehicles or boats, or for loading tank trucks or tank cars, shall be positive displacement meters. Turbine meters may be used for larger volume steady state transfers such as loading ships or barges or pipeline transfers.

All meters shall meet the accuracy requirements of the National Bureau of Standards Handbook 44, Liquid Measuring Devices, latest edition. All meters should be equipped with an adjustable calibrator between the meter and the register. All meter piping shall include connections or similar means so that the meter can be calibrated against a prover of known accuracy such as a fixed or portable volumetric prover, a master meter, or a pipeline prover. All

meters shall be protected by a strainer on the upstream side. Meters which may be subject to the passage of air or vapor shall be equipped with a deaerator. Meters shall be protected against mechanical damage from overspeeding by a flow control device.

Meters used for loading tank trucks, except aircraft refuelers, should be equipped with a two-stage preset control device capable of stopping the flow when the preset quantity is delivered. The preset device should be electrically connected to a diaphragm control valve with a high flow and a low flow pilot valve. The high flow pilot should be equipped with an adjustable time delay relay arranged so the high flow pilot will not open for a period of 1 to 2 minutes after the start of flow, and stop the flow with a high flow, low flow sequence.

In conjunction with the installation of meters, the use of a card or key operated data acquisition system should be considered. Cards or keys, as appropriate, are coded to identify the receiver of the fuel and to give him access to it. The quantities taken are transmitted to a data receiving device by electronic pulse transmitters mounted on each meter, and each transaction is automatically recorded.

In interterminal pipelines, the possible use of a turbine meter at each end of the line should be considered as a means of protection against undetected leaks or pilferage.

b. Pressure Gages. Use pressure gages of range and dial size as necessary, but not less than 0 to 160 pounds per square inch pressure range and 4-1/2-inch diameter dial, on the discharge side of each fuel pump, the inlet and outlet of each fuel oil heater, and on fuel pipelines at each loading or receiving point in accordance with ANSI B40.1-74, Gages, Pressure and Vacuum, Dial Indicating. Also:

(1) Use pressure gages upstream and downstream of strainers, filters/separators, and cartridge type fuel quality monitors. Differential pressure gage may be used in lieu of gages on each side.

(2) Install compound gages on the suction side of each pump at fuel storage tanks.

(3) Provide a lever handle gage cock in each pressure gage connection.

(4) Provide indicating and recording pressure gages on suction and discharge lines for interterminal pipeline pumping stations and on the incoming line at the delivery terminal of each such pipeline.

c. Thermometers. Provide thermometers in #5 and #6 burner fuel distribution piping systems at each loading and receiving point and on the inlet and outlet of each heater. For thermometers at fuel storage tanks, see Chapter 4, Section 3, paragraph 7f.

d. Strainers. The requirement for the protection of centrifugal pumps by a strainer should be carefully considered in the light of the operating service condition versus the adverse effect of the strainer on the pump

suction head and the cost to install and maintain the strainer. Whether or not strainers are installed on the suction side of centrifugal pumps, install a spool piece so that temporary strainers can be installed during startup of the system. Strainers are required on the suction side of all positive displacement pumps and meters. Strainers are not required upstream of filter/separators or diaphragm control valves, except as noted in Chapter 1, Section 2, paragraph 3f(11).

Strainers shall be of steel construction and fitted with removable baskets of fine Monel metal or stainless steel mesh with large mesh reinforcements. Unless otherwise specified, the mesh of a fine screen shall be as follows:

	Mesh Per Inch
Pump suctions, all products	7
Meter inlets, light fuels	60
Meter inlets, residual fuels	20

In all cases the effective screen area should be not less than three times the cross sectional area of the pipe.

In facilities which receive product by tankers or barge, the use of solid separators in the receiving lines should be considered to remove gross impurities from the incoming product. In systems equipped with filter/separators in the receiving lines, strainers or cyclonic separators shall be located upstream of the filter/separator.

e. Surge Suppressors. Where it is practical to do so, it is preferable that hydraulic surge or shock be controlled to acceptable limits by the design of the piping and valves rather than by use of surge suppressors. This can usually be done by avoiding the use of quick closing valves and by limiting the velocity of the flow in the system. The shock effect is caused by suddenly stopping the fluid flow which converts the kinetic energy of the moving column of fluid into pressure. For every part of every system there is a critical valve closure time that will develop full shock. This can be calculated by the following formula:

$$T_c = \frac{2L}{a} \quad (1-1)$$

WHERE: T_c = Critical closure time in seconds.

L = Length of the system from the valve back to the nearest atmospheric tank, in feet.

a = Velocity of the shock wave in feet per second.

Values of "a" for liquid petroleum in schedule 40 steel pipe are as follows:

Nominal Pipe Size	Shock Wave Velocity
2"	4,455 ft/sec.
3"	4,410
4"	4,370
6"	4,250
8"	4,230
10"	4,132
12"	4,060

In a system of 8 inch pipe which measures 1,000 feet from the storage tank to a shutoff valve, the critical closing time would be 0.47 seconds. If it were 2,000 feet long the critical time would be 0.94 seconds. In either system, if the valve closed more quickly than the critical time, the shock pressure generated would be approximately 42 psi for each foot per second change in the velocity of flow. A dead shutoff against a flow of 1,600 gallons per minute would create a shock pressure 346 pounds per square inch above the shutoff pressure of the pump. If the flow rate were 800 gallons per minute the shock pressure would be 173 psi. (For additional information, see Crocker and King, Piping Handbook.)

Most systems that will be designed in accordance with this manual will use ANSI Class 150 flanges and these systems shall have a maximum allowable working pressure of 275 psi at 100° F. This means that the total pressure including shock, pump shutoff pressure and static pressure in any part of the system, should never exceed 275 psi. Other equipment items such as aircraft fuel tanks, tank trucks or shipboard fuel tanks which may be damaged by shock pressures resulting from a shutoff in some other part of the system may require that a lower maximum shock pressure will govern the design. An instantaneous shutoff by the aircraft should also be considered in the design of these systems.

If it is determined that surge suppressors should be used, they should be of the diaphragm or bladder type located as close as possible to the point of shutoff that causes the shock. Surge suppressors should be constructed in accordance with the ASME, Boiler and Pressure Vessel Code, Section VIII. Surge suppressors can reduce shock pressure by as much as 40 percent but will not eliminate it entirely. Conservative piping design, use of loops and slow closing valves, say about 1-1/2 to 2 second closure time, are the best solutions to the shock problem.

f. Filter/Separators. Filter separators are required for all aviation fuel systems, both jet fuel and avgas, in facilities where the fuel is dispensed directly to aircraft or is loaded on refuelers which will in turn dispense the fuel to aircraft. As a minimum for such facilities, filter/separators shall be provided at the following locations:

- (1) In receiving lines upstream of all operating storage tanks.
- (2) In supply piping to refueler truck fill stands.

(3) On the discharge side of transfer pumps that supply aircraft direct fueling stations.

Filter/separators shall be designed and constructed in accordance with the following military specifications, as appropriate:

300 gal/min capacity, MIL-F-27629, Filter/Separator Liquid Fuel, FFU-1/E

600 gal/min capacity, MIL-F-2760, Filter/Separator Liquid Fuel, FFU-2/E

1200 gal/min capacity, MIL-F-83402, Filter/Separator Liquid Fuel, FFU-25/E

Performance and Testing, MIL-F-8901, Filter/Separator Liquid Fuel and Filter Coalescer Element, Fluid Pressure, Inspection Requirements and Test Procedures for.

Filter/separators shall be designed and constructed in accordance with the ASME Code for Unfired Pressure Vessels. Metal parts which will be in contact with the fuel, including the shell, head and internal attachments, shall be constructed of 3003 or 6061 aluminum alloy. Accessories shall include the following:

- (1) Differential pressure gage with 1 psi graduations across the elements.
- (2) Sight glass on the water pump.
- (3) Diaphragm operated control valve in the main discharge with a flow limiting pilot and a float operated pilot to close the main valve if the water level in the sump rises above the set point.
- (4) Automatic, float controlled, diaphragm operated water drain valve from the bottom of the water sump.
- (5) Manual water drain valve from the bottom of the water sump.
- (6) Head lifting device.
- (7) Pressure relief valve.
- (8) Automatic air release.
- (9) Strainers are required upstream of filter/separators when the filter/separator is upstream of operating storage tanks.
- (10) Automatic water drains, manual drains, pressure relief valves and air releases shall be connected to a permanently installed waste system.

g. Fuel Quality Monitors. Fuel quality monitors of the cartridge type shall be similar in construction and materials to filter/separators except that the elements shall be designed to gradually stop the flow of fuel when the quantity of dirt or water in the elements causes a significant increase in differential pressure.

Fuel quality monitors shall be constructed in accordance with Military Specification MIL-M-81380, Monitor, Contamination, Fuel Dispensing Systems, and meet the performance requirements contained therein except the elements shall be of the type that absorb and retain free and emulsified water without being affected by surfactants or additives in the fuel and shall filter particulate matter. Differential pressure gages with one psi graduations shall be provided. This type of monitor shall be provided on the downstream side and adjacent to the filter/separators serving refueler fill stands and fixed aircraft fueling stations.

Electronic fuel quality monitors of the type that monitor fuel turbidity shall be provided on the downstream side of filter/separators in the fuel receiving piping.

4. **SAMPLING AND TESTING FACILITIES.** Provide connections for sampling fuels on each section of a fuel transfer piping system.

Install sampling and testing connections at: receiving points, tank outlets, inlet and outlet sides of filter/separators and fuel monitors, all fuel dispensing points, and at each side of a block valve so that the remaining fuel in each portion of a fuel transfer pipeline can be sampled. Where possible, install sampling connections in vertical runs. A sampling connection shall be a flush type dry break quick disconnect with dust cap.

Provide a fuel facility laboratory with space for necessary laboratory equipment. Electrical equipment and installation, to a point 18 inches above the floor within fuel facility laboratories, should be suitable for Class I, Group D, Division 2 hazardous locations (as defined in NFPA 70, National Electric Code).

5. **ABOVEGROUND PIPING.** Aboveground piping is preferred where it is not aesthetically objectionable or when it may be subject to physical damage, either accidental or deliberate. Limit the use of underground piping to those areas where it is not practical or safe to install piping aboveground.

Support aboveground piping so that the bottom of the pipe will be approximately 18 inches above the ground. In areas subject to flooding, greater clearance may be desirable. At intersections with roadways, allow enough clearance for the passage of trucks, cranes, and similar heavy vehicles. Space supports in accordance with Table 4.

Piping on supports, both insulated and uninsulated, shall rest on a steel shoe welded to the bottom of the pipe. The shoe should be left free to move on the support. Figure 3 shows the design of a typical pipe support.

Anchors and guides may also be required to control movement in long runs of straight pipe or near a connection to fixed equipment such as a pump or filter.

Piping on piers shall be run above the pier deck wherever possible.

6. UNDERGROUND PIPING.

a. Depth of Cover. Depth of cover over buried fuel pipelines shall be governed by the following:

(1) Top of lines shall be below design frostline, except that less cover is permissible for occasional stretches where overriding conditions exist, such as the need to pass over a large culvert and beneath drainage ditches. At such locations, sufficient slack shall be built into the line to allow for vertical and lateral movement due to frost heave. Protective measures, such as the installation of reinforced concrete slabs above the pipe, may also be required where depth is less than required under paragraph (2) below.

(2) Subject to (1) preceding minimum depths shall be as specified in 49 CFR 195, Federal Safety Regulations for Liquid Petroleum Pipelines, Sections 195.248 and 195.210, except that under roadways and shoulders of roadways, minimum depth shall be 4 feet.

b. Casing Sleeves. Use steel casing sleeves for those crossings where sleeves are required by authorities having jurisdiction, where it is necessary to bore under the roadway or railroad to avoid interference with traffic, or where boring is the most economical construction method. When planning construction of open trench crossings, the economics of installing spare casing sleeves to eliminate excavating for future fuel lines should be studied carefully. Fuel carrying lines shall be carefully insulated against contact with the casing pipes. The annular space at each end of the casing shall be carefully sealed. A vent shall be installed on the higher end of each casing. Crossings shall be located at a minimum depth of 36 inches beneath the bottom of drainage ditches. If this depth cannot be obtained, a 6-inch reinforced concrete slab of adequate length and width to protect the casing or pipe from damage by equipment such as ditch graders and mowers, shall be installed above, but not in contact with, the casing or pipe. (Refer to API RP-1102, Recommended Practice for Liquid Petroleum Pipelines Crossing Railroads and Highways, for additional information on this subject.)

c. Corrosion Protection. All new underground cross country pipelines shall be coated or wrapped and have cathodic protection in accordance with 49 CFR 195. (See NAVFAC TS-09809, Protection of Buried Steel Piping and Tie Rods.) All other underground piping which is coated or wrapped shall have cathodic protection.

d. Excavation and Backfill. Excavation and backfilling shall be done in accordance with NAVFAC Specification TS-02202, Earthwork for Utilities.

e. Line Markers. Except where national security considerations prohibit them, line markers shall be installed and maintained over each buried line not located on Navy property, in accordance with Section 195.410 of 49 CFR 195, Federal Safety Regulations for Liquid Petroleum Pipelines.

7. UNDERWATER PIPING.

a. Depth of Burial. Depth of underwater pipelines below the bottom shall be sufficient to prevent damage by dredging of the waterway, by ships'

anchors, trawls, or by scouring action of the current. Specifically, the depth shall conform to the requirements of Section 195.248 of 49 CFR 195. Where lines cross ship channels or anchorages, the top of the pipe shall be at least 12 feet below the theoretical present or planned future bottom elevation, whichever is deeper. Recommended backfill in such areas is 2 feet of gravel directly over the pipe, followed by stones weighing 50 to 60 pounds up to the bottom elevation.

b. Pipe Thickness and Weight. Pipe wall thickness shall be sufficient to keep stresses due to maximum operating pressure and other design loads within design limits. This shall include full consideration to extra stresses which may occur in laying the pipe.

It is common practice to use heavier wall pipe for water crossings of more than 200 feet from bank to bank at normal water level. This affords greater stiffness and resistance to buckling during handling of the assembled crossing pipe, and requires less weighting material to obtain the necessary negative buoyancy to keep the line in place while empty or containing a light product. All underwater lines shall be coated and wrapped and provided with cathodic protection. (See Chapter 6 for criteria.) Reinforced "gunite" is an acceptable weighting material. Assembled crossing pipe should be hydrostatically tested before placing, unless crossing pipe is too long for prior assembly in one stretch, in which case each stretch shall be separately tested as described.

c. Valves. Underwater pipes which are more than 100 feet bank to bank at normal water level shall have a dependable and readily accessible shutoff valve on the shore on each side of the crossing. There shall also be a check valve on the downstream side of the crossing.

d. Meters. Pipelines which include one or more water crossings 200 feet or more from bank to bank shall be equipped with at least two turbine meters, one on either side of the crossing(s). The meters shall be equipped with a registration system that will monitor and compare the volume registered by each meter and create an alarm signal when the outputs from the meters do not compare favorably.

e. Pigging Equipment. Pipelines which include one or more water crossings 200 feet or more from bank to bank shall be equipped with pig launchers and traps. The design of launchers and traps shall be such that they can accommodate internal nondestructive inspection trains. The curvature of bends in the pipeline shall be large enough to allow free passage for such equipment.

Section 3. PUMPS

1. DESIGN REQUIREMENTS. Pumps must be designed to deliver the full range of operating conditions anticipated at any activity with minimum flow rates as given in Table 2. The pump must develop sufficient head to overcome the friction and static head losses in the system at rated flow. The specific gravity, temperature, viscosity, vapor pressure, corrosive, and solvent properties of the fuel must be considered in pump selection and design.

Pumps should be selected according to the type most suitable for the particular application. Examples are:

a. Centrifugal Pumps. Centrifugal pumps are preferred for pumping from aboveground tanks with continuously flooded suction.

b. Vertical Turbine Pumps. Vertical turbine pumps are preferred for pumping from underground tanks. Horizontal transfer pumps in a pit alongside the underground tank shall not be used.

c. Rotary Pumps. Rotary pumps or selfpriming centrifugal pumps shall be used for applications such as stripping pipelines, pumping out tank trucks or cars or similar service where the pump may frequently lose its prime.

Rotary pumps shall be used for pumping viscous liquids where there is no reliable heat source.

d. Drivers. Where a reliable source of sufficient electric power is readily available, permanently installed pumps shall be driven by an electric motor which is properly classified in accordance with NFPA 70. Where a reliable source of electric power is not available, pumps may be driven by an internal combustion or steam engine. When such engine drives are in enclosed pump houses, provide a vapor wall between the engine and the pump.

e. Materials of Construction. Pumps used for petroleum services, except aircraft fueling systems or to refuelers, shall have carbon steel or nodular iron casings with stainless steel drive shaft. Pumps for aircraft fueling systems or aircraft refueler loading systems shall have stainless steel casings, shafts and impellers.

Except on multi-product pipelines provide separate pumps for each of the following types of fuels:

- (1) Burner fuel oils.
- (2) Diesel fuel.
- (3) Jet fuel. (Separate pump for each type.)
- (4) Gasoline. (Separate pump for each type.)
- (5) Kerosene.
- (6) LPG.

All jet and diesel fuel systems shall have at least two transfer pumps each capable of delivering the required system capacity.

f. Installations. Permanently installed pumps shall be mounted on substantial foundations of reinforced concrete designed in accordance with Hydraulic Institute Standards. Provide drain piping for pump and motor base, pump gland, or seal leakage and vent valve. Connect drains to an oil-water separator or waste tank with piping which includes a vertical liquid trap.

Military specifications which are applicable to liquid petroleum pumps are:

- MIL-P-13386 - Pumps, Centrifugal, Multi-Stage, Vertical.
- MIL-P-17608 - Pump, Rotary, Power Driven.

MIL-P-17597 - Pump/Heater, Fuel Oil.

MIL-P-21214 - Pumps, Centrifugal Vertical Sump.

Another applicable specification is:

API Standard 610, Centrifugal Pumps for General Refinery Service.

Section 4. HEATERS

1. **HEATING MEDIUM.** The heating medium should be appropriate for the particular application with consideration to temperature, pressure, and availability. Saturated steam is the preferred heating medium but hot oil, hot water, and electric heating should be considered where steam is not available from existing sources.

2. **FUEL OIL HEATERS.** Heavy burner fuel oils should be heated to a temperature that will develop an optimum pumping viscosity. For #6 fuel oil this will generally be in the range of 120° F to 130° F. (See Figure 1 for the change of viscosity with temperature.) The types of heaters which may be used are as follows:

a. **Convection Type Heaters.** Install this type inside a storage tank. It must be capable of passing through a 24-inch manhole. Convection type tank heaters shall each have a capacity which will raise the temperature of a full tank of burner fuel oil approximately 60° F in 24 hours.

b. **Inline Heaters.** These heaters are of shell and tube construction of two general types. One type has one open end for installation on the outlet fuel line inside a tank (such as a bayonet type heater), and the other type has both ends closed for installation in the pipeline outside a tank. Inline heaters shall be designed in accordance with the following:

(1) Inline heaters must be capable of heating fuel oil passing through them from the ambient tank temperature to 120° F.

(2) Inline heaters installed in tanks shall be designed to allow removal of heater tube bundles without emptying the tank.

(3) In multipass inline heaters, the oil temperature rise shall not exceed 30° F per pass.

(4) Shells shall be carbon steel designed for a minimum 175 pounds per square inch cold working pressure on both steam and oil sides.

(5) The pressure drop on the oil side of pump suction line heaters must not exceed 0.2 pounds per square inch, or exceed 10 pounds per square inch for heaters installed on pump discharge.

(6) For subsurface tanks, heaters can be mounted through the same openings used for vertical pump mounting.

3. **INSULATION AND TRACING.** In all cases where fuels must be heated, the design should examine the possible economic incentives for insulating heated

storage vessels and piping. In many cases, piping carrying heated products must be steam traced to prevent possible solidification of the fuel during a shutdown period. Traced lines shall also be insulated. The economic study should also consider possible incentives for installing a condensate collection and return system. In a condensate return system is installed, a monitor to detect oil in the condensate shall also be installed.

Install thermometers and automatic temperature controls in all heated tanks and heat exchangers.

4. LPG VAPORIZERS. (See Chapter 9, Section 4.)

Section 5. CONTROLS

1. **DESIGN REQUIREMENTS.** Automatic controls at any facility may include temperature, pressure, fuel level and pump controls, automatic flow controls, alarm and limit switches, motor and pilot operated valves, and remote system condition indicators. Other forms of automated controls such as remote meter indication, electronic access control, data logging, and application of computer techniques should also be considered.

Selection of advanced automation and telemetry systems should be based upon a study of the particular application with consideration to possible economic justification, operational, and security requirements.

2. **TEMPERATURE CONTROLS.** Provide temperature controls at all fuel oil heaters to control the outlet oil temperature within safe limits. Use controls in which each consists of a sensing element in the fuel outlet line which activates a thermostatic valve or switch in the heating medium supply connection to the heater. The control valve must be self actuating and require no external power for closure. Each temperature shall have a manually adjustable set point, variable over the desired temperature range. Provide a bypass around the control valve with a throttle valve for manual operation.

3. **FLOW CONTROLS.** Where it is possible to achieve flow rates which exceed equipment ratings, each meter or filter/separator shall have an adjustable flow control valve on the outlet connection. Use a self actuating control valve controlled by the pressure differential across an orifice plate or venturi in the main line.

4. PUMP CONTROLS.

a. **Transfer pumps.** Parallel transfer pumps supplying an issuing facility with varying demand flow rates must be sequenced automatically by flow sensing sequence equipment. Lead pumps can be started by a pushbutton at an issuing facility, or automatically by a pressure switch actuated by a decrease in system pressure as might be caused by opening a valve at the issuing facility. This method requires the system to be pressurized at all times. The design shall incorporate use of the following control features:

(1) Automatically controlled pumps shall have emergency stop buttons with lock-key reset at issuing stations and at the central supervisory control station.

(2) Transfer pumps shall shut off automatically on loss of suction, no flow for more than 3 minutes, or excessive flow such as from a line or hose break. Such automatic shut off shall activate a corresponding alarm at the central supervisory control station. (See NAVFAC P-272, Definitive Designs for Naval Shore Facilities, NAVFAC Drawing 1311355, Control System for Naval Fuel Depot.)

b. Pipeline Pumps. For pumps over 150 horsepower, such as in a pipeline station, provide protective shutdown devices with alarm at central supervisory control station in the event of:

- (1) High pump case temperature due to blocked discharge.
- (2) Excessive pump vibration.
- (3) Mechanical seal or packing gland failure.
- (4) High discharge pressure or loss of discharge pressure.
- (5) Excessive motor vibration.
- (6) High motor winding temperature.

(7) Electrical interlocks which will prevent starting a pump if certain key valve settings are not correct, and which will cause a pump shutdown if a key valve setting is changed. (See NAVFAC P-272, NAVFAC Drawing 1311355, Control System for Naval Fuel Depot.)

c. All Pumps. For both transfer and pipeline fuel pumps, provide the following controls:

- (1) A stop-lockout button at each remotely operated pump for maintenance operation.
- (2) Indicator lights at the control station to give positive indications both when a pump is operating and when it is not energized. All indicating lights shall be the "push-to-test" type.
- (3) A signal light or alarm to indicate pump failure when a pump is controlled automatically.
- (4) Other features as shown on NAVFAC Drawing 1311355.

Where necessary, provide remote operated valves on storage tank inlet and outlet lines, suction and discharge of transfer pumps, and transfer lines at fuel piers and other locations. Operation of pump suction and discharge valves may be a part of the automatic sequence for the starting of a centrifugal pump and for shutting it down, remotely, locally, or by a protective shutdown device. (See NAVFAC P-272, NAVFAC Drawing 1311355, Control System for Navy Fuel Depot.) Remote operated valves can be either motor operated or the solenoid pilot type, hydraulically operated by piston or diaphragm. Such valves shall have green and red (open and closed) indicating lights at their pushbutton control locations.

5. LEVEL CONTROLS. Provide automatic gaging devices and high and low level controls on all storage tanks.

a. Gaging Devices. The automatic gage shall be a float or similar device with a readout which is readily accessible and visible at eye level from the ground immediately adjacent to the tank. The readout shall be of a type that is compatible with a remote reading system. Remote reading systems shall be installed only when specifically authorized.

Where a remote reading system is to be installed, it shall be digital encoding type. Mechanical gage measurements shall be converted at the tank gage into a serial digital message which shall be transmitted to a central microprocessor. Temperature probes inserted in the tanks will furnish an analog signal which will be field encoded and transmitted digitally by the same transmitter. System shall be capable of reading tank levels to $\pm 1^{\circ}$ F. The microprocessor and its software shall be capable of displaying:

- (1) Volume in barrels or gallons. Calculated from tank strapping tables.
- (2) Volume corrected for API gravity, temperature and/or floating roof heads.
- (3) Product temperature.
- (4) Alarm conditions (high or low).

Alarm limits shall be keyboard adjustable from the microprocessor.

b. High Level Alarms. High level alarms shall be mechanically and electrically independent of the gaging device. Two alarm levels shall be provided. One alarm level shall be set at approximately 95 percent of the safe tank filling height arranged to actuate an audible alarm signal located at or near the normal station of the person in control of the tank filling operation. The second alarm level shall be set at approximately 98 percent of safe filling height. It shall continue the audible alarm and, in addition, actuate a visible alarm and close an electrically actuated valve to stop the flow in the tank inlet line or to stop product supply pumps if they are controlled only within the terminal.

c. Low Level Alarms. The low level alarm may be actuated by appropriate electrical contacts on the automatic gaging device. The low level alarm shall actuate an audible alarm which is distinctive from the high level alarm and stop product transfer pumps which may be taking suction from the tank.

6. INTERTERMINAL PIPELINES. In NAVFAC P-272, NAVFAC Drawing 1311356, Control System for Interterminal Pipeline, contains essential details for the control system of an interterminal pipeline which can be operated by one man on duty at a central supervisory control station. In addition to being able to remotely control the pump stations, the equipment must be able to handle some operating functions at the originating and delivery terminal tank farms. These include remote reading of tank gages and temperatures, opening and closing tank valves, and obtaining high tank level alarms. Low tank level alarms are

optional equipment. At a large fuel depot at one end of an interterminal pipeline, it might be feasible and economical to place the control center for the fuel depot operations in the same room with the pipeline control station. (See NAVFAC, P-272, NAVFAC Drawing 1311355.)

Interterminal pipeline design may also include meters at both ends of the line or at some other appropriate interval for the purpose of leak detection.

Section 6. ANTISTATIC DESIGN

1. **DESIGN REQUIREMENTS.** Make a special design study of all divisions of fuel receiving, storage, distribution, and dispensing facilities to eliminate or minimize fire and explosion hazards which are possible as a result of static electricity generated in fuel handling operations. Derive design criteria for specific installations using methods described in Electrostatic Discharges in Aircraft Fuel Systems, Coordinating Research Council (CRC) Inc., New York, API Bulletin 1003, Precautions Against Ignition During Loading of Tank Truck Motor Vehicles, and API RP 2003, Protection Against Ignitions Arising Out of Static, Lightning and Stray Currents.

Because of the many variables involved, such as properties of fuels and geometry of equipment layouts, no specific limits are established for design factors such as flow velocities. However, the following design features should be considered:

- a. Piping Inlet Connections. Design connections to tanks, vessels, or equipment for reduced velocity and to prevent splashing.
- b. Enclosed Vapor Spaces. Spaces above flammable hydrocarbons in tanks or other liquid containers must not have any sharp projection or probes which could be focal points for static electricity discharges.
- c. Drop-Arm Outlet Details. Design these outlets on truck and railroad fill stands to prevent splash filling.
- d. Filter/Separators and Fuel Quality Monitors. The heaviest electrostatic charges are usually developed in filtering elements of this equipment. The design should attempt to reduce such charges before fuel is transferred into storage tanks, vehicle tanks or any equipment containing vapor spaces. By means of residence time in piping or in a relaxation tank, provide 30 seconds relaxation time between this equipment and the point of discharge.
- e. Aircraft Direct Fueling Stations. These stations are used for dispensing fuel to aircraft. The fuel requires 30 seconds residence time in the piping or in a relaxation tank before being discharged into the aircraft to remove high electrostatic charges that may be generated by the filtering elements of a filter/separator or cartridge type fuel quality monitor. Where possible, piping should be designed to provide the required 30 second relaxation time without use of a relaxation tank.
- f. Bottom Loading. Bottom loading should be used for all truck loading facilities. For additional information on the control of electrostatic charges, refer to NFPA Standard 77, Static Electricity, API Bulletin 1003 and API RP 2003.

Section 7. ELECTROMAGNETIC RADIATION HAZARD

1. DESIGN REQUIREMENTS. The design of petroleum storage, dispensing, or handling facilities shall give consideration to the potential hazards that may be created by emissions from electromagnetic devices such as radio and radar.

a. Clearance Restrictions. The following specific precautions and restrictions shall be incorporated in the design of petroleum fuel facilities:

(1) Radio transmitting antennas should be located as far as practically possible from fuel storage or transfer areas.

(2) Fuel storage or transfer facilities shall not be located closer than 300 feet from aircraft warning radar antennas.

(3) Fuel storage or transfer facilities shall not be located closer than 500 feet from airport ground approach and control equipment.

(4) Fuel storage or transfer facilities shall not be located closer than 300 feet from areas where airborne surveillance radar may be operated.

(5) Fuel storage and transfer facilities shall not be located closer than 100 feet from airport surface detection radar equipment.

(6) For additional details see MIL Handbook 238 (Navy), Military Standardization Handbook, Electromagnetic Radiation Hazards.

CHAPTER 2. RECEIVING FACILITIES

Bulk fuel deliveries to a naval activity are made by water transport, tank truck, railroad tank car, or pipeline. Each facility should be designed so that a secondary method of fuel delivery to the facility is possible. When instructed by NAVFACENCOM HQ, the designer shall be required to make a study to determine the most appropriate methods of transport.

The basic design of fuel receiving facilities shall comply with Chapter 1.

Section 1. MARINE RECEIVING FACILITIES

1. **FUEL PIERS AND WHARVES.** The structural design of fuel piers and wharves shall be in accordance with NAVFAC DM-25, Waterfront Operational Facilities. The functional design shall be in accordance with NAVFAC P-272, Definitive Drawing 1403995 through 1403999, Non-Polluting Fuel Piers. The design of fuel piers shall also comply with the U.S. Coast Guard oil pollution regulation, 33 CFR, Part 154. When required, fuel piers may be designed for dispensing as well as receiving fuel. The size of the facility shall be compatible with the fuel requirements of the activity and the number of simultaneous loadings and unloadings to be accommodated. (See Table 2 for fuel transfer flow rates.)

a. Equipment. Pier facilities shall include the following equipment:

(1) Pipe manifolds for each fuel type arranged parallel to the face of the pier.

(2) Articulated marine loading arms for receiving and shipping fuel cargoes. Articulation of the loading arms shall be such that the connected vessel can move 15 feet forward, 15 feet aft and 10 feet off the face of the pier and vertically as caused by loading or unloading of the vessel and tidal changes, without damage to the arm.

Marine loading arms larger than 8-inch nominal size shall be operated by an hydraulic power assist system. The end of the loader to be connected to the ship's manifold shall be equipped with an insulating section, a standard ANSI forged steel flange and, when appropriate, a steel quick coupling device, manually or hydraulically operated.

(3) Cargo hose, hose racks, and hose shelters.

(4) Bilge and ballast connections.

(5) Positive displacement stripper pumps for emptying loading arms, hoses, and manifolds.

(6) Spill containments in compliance with Coast Guard regulations and, where required, NAVFAC P-272, NAVFAC Drawing No. 1311353, Oil Spill Containment for Berthing Facilities.

(7) Sampling connections and equipment.

(8) Communications facilities with connections to pump house, tank field stations, and the vessel alongside.

(9) Fire protection equipment in accordance with Chapter 7. (Also see NFPA 87, Piers and Wharves.)

(10) Lighting in accordance with U.S. Coast Guard requirements.

(11) Personnel and equipment shelter.

(12) Oil spill recovery equipment at or near the pier.

(13) An energy absorbing fender system.

b. Piping Layout and Design.

(1) Where simultaneous deliveries of the same fuel may be made by more than one vessel, size fuel headers and related equipment for the total flow rates of all vessels discharging into the headers. Individual flow rates shall be in accordance with Table 2.

(2) Pier piping should be placed above the pier deck. Piping should slope toward shore to permit stripping. Use gratings as required to allow access across the piping.

(3) Each line should have a block valve at the shore end. Piping used only for receiving fuel should also have a check valve at the shore end. Block valves may be motor operated with remote control.

(4) Piping between the pier and the shore should have flexibility to allow for small movement of the pier relative to the shore. Use a suitable pipe bend or offset configuration, preferably in a horizontal plane, that will allow three dimensional movement. If vertical bends are used, install vents and drains.

(5) In piping used for unloading only, provide a nonsurge check valve near the base of the marine loading arm to minimize loss of fuel in case of damage to the loading arm. In piping used for both loading and unloading, equip the valve with a level for manual operation.

(6) In piping used for both loading and unloading, provide a sensor to detect excess flow as might occur in the event of a line break. The excess flow sensor should be designed to close a remote operated block valve. (See NAVFAC Drawing 1311355, Control System for Naval Fuel Depot.)

(7) Provide thermal relief valves around all block and check valves that can isolate a section of piping.

(8) Provide electrically insulated joints in all fuel lines where the shore end is under cathodic protection or where the pier structure is under cathodic protection. In the latter case, the piping should be bonded to the pier structure but electrically isolated from the ship.

c. Security. Provide security fencing in accordance with NAVFAC DM-5.12, Fences, Gates and Guard Towers, to prevent unauthorized access from the shore to the pier.

d. Corrosion Protection. Piles and other steel members used for bracing and the support of fuel piers should be coated prior to installation. Cathodic protection should be applied promptly for protection of the submerged steel. (See Chapter 6 for coating and cathodic protection requirements.) At piers where low flash fuels are handled or may be handled in the future, the following safety features shall be provided:

(1) Provide an insulating joint or an insulating length of hose between the pier piping and the ship. In the case of metal loading/unloading arms, the best procedure is to insulate them at their bases, and also insulate all hydraulic control, vent, and drain lines, in addition to the conductor pipe.

(2) Provide a heavy bonding cable with heavy duty C-clamp for attachment to vessel and suitable explosion-proof switch for closing and opening the circuit. This will reduce, but will not eliminate, the electrical potential between ship and pier. An ammeter in the circuit will enable the reduction in potential and approximate power transferred to the ship to be calculated.

2. OFFSHORE MOORINGS.

a. Moorings. When operations of an activity do not warrant construction of fuel piers, provide offshore moorings for vessels to discharge or receive fuel through underwater pipelines connecting to the shore facility. Moorings should be clearly marked so that the vessel, when moored, will be in the proper position to pick up and connect to the underwater connection. (See NAVFAC Standard Y and D Drawing No. 896129, Fuel Loading Type Mooring for details of such a mooring arrangement.) For other details, see NAVFAC DM-25, Waterfront Operational Facilities, and Advanced Base Drawing NAVFAC P-437, NAVFAC Drawing 6028008, Pipeline F/6 Inch Amphibious Assault Submarine Fuel Line, NAVFAC Drawing 6028064, Pipeline, Welded, Sea Loading, 8 Inch Basic Depth 60 Feet. NAVFAC P-272, NAVFAC Drawing 1293330, Wharf and Offshore Fuel Terminal Configuration and NAVFAC Drawing 1293316, Offshore Tanker Facilities.

b. Underwater Piping. To receive fuel from offshore moorings, provide one or more underwater pipelines from the shore facility to the mooring in accordance with Chapter 1, Section 2, paragraph 7. At the mooring end of each pipeline, provide lengths of submarine fuel hose equal to 2-1/2 times the depth at high water. At the pipe end of the hose, provide a flanged removable section of hose 10 feet long. At the free end of the hose provide a steel valve with a marker buoy attached to a cable or chain which has sufficient strength and suitable fittings for the vessel to lift the hose and valve aboard.

Lay out multiple fuel lines and connections so that they correspond to the layout of the ship's discharge manifold.

In piping design, consider fuel characteristics as they may be affected by the sea water temperature, particularly in cold water. For diesel fuel, jet fuel, or other light fuels, small individual lines are preferable as follows:

- (1) Minimum line size shall be 6-inch.
- (2) For large capacity transfer of fuels use 12- to 16-inch lines.

(3) If lines larger than 16-inch are considered necessary, use two smaller lines instead.

(4) At an accessible upland location, as close to the water entry as practical, provide a steel block valve and a manually operated check valve or bypass to allow reversal of flow when required.

(5) Provide a dependable means of communication between the vessel in the offshore berth and the shore facility.

c. Corrosion Protection. Underwater pipelines shall be wrapped, coated, and cathodically protected in accordance with Chapter 6.

d. Submarine Fuel Hose. Submarine fuel hose shall be heavy duty, smooth bore, oil and gasoline, marine cargo, suction and discharge hose rated for a working pressure of not less than 225 psi, a suction vacuum of 20 inches of mercury and shall have built in nipples with Class 300 flanges with stainless steel bolts and Monel nuts.

Section 2. PIPELINE RECEIVING FACILITIES

1. FUNCTION. Petroleum fuels may be supplied to naval fuel storage tanks by interterminal pipelines. Pipelines may be dedicated to serving the particular facility or may be commercial common carrier pipelines handling a number of types or grades of fuel for more than one user.

2. DESIGN REQUIREMENTS. The design of pipeline receiving facilities shall include the following features and equipment:

a. Fuel Segregation. Separate all fuel grades in accordance with Chapter 1, Section 1, paragraph 6.

b. Pressure Regulating Valves. Provide pressure regulating valves to reduce pipeline pressures to the design pressure of the facility equipment. Provide a block valve at both upstream and downstream sides of each pressure regulating valve.

c. Meters. Provide a turbine type meter at the receiving end of the line to measure quantities of fuel received. Install a strainer on the upstream side of the meter and connections for proving the meter with a portable prover.

d. Sampling. Provide sampling means for each pipeline product at a breakout manifold.

e. Scrapers. Provide scraper receiving traps with required valving and pig indicating devices.

f. Interface Tank. Provide where required.

g. Booster Pumps. Provide booster pumps when needed to obtain required flow rates.

h. Control Valves. On a pipeline requiring more than one pump station operating in series, provide a control valve on the discharge line of each pump station with automatic controller-recorder to reduce flow if suction pressure tends to fall below the set point, or if discharge pressure tends to rise above the discharge set point, and to record these pressures. Further information on control valves and protection shutdown devices to keep pressures within allowable limits is given in NAVFAC P-272, NAVFAC Drawing Number 1311356, Control System for Interterminal Pipeline.

i. Corrosion Protection. Underground pipelines should be wrapped, coated, and cathodically protected as described in Chapter 6.

Section 3. TANK TRUCK AND TANK CAR RECEIVING FACILITIES

1. FUNCTION. Fuel storage facilities not on navigable waters or not near a pipeline may be supplied with fuel by tank truck or by tank car or both. Large facilities which have pipeline or water transport for their principal supply may also have tank truck or tank car deliveries as a secondary source of supply, or for secondary fuels such as burner fuel oils, motor gasoline, or aviation gasoline which are used in relatively small quantities.

Tank truck deliveries are by far the more common method in use at this time. There may, however, be special transportation considerations or changing circumstances which would make the use of rail facilities desirable. It is therefore desirable that a tank truck receiving facility at an activity with railroad service should be laid out so that the tank truck receiving system could be easily and economically extended to existing rail sidings.

2. LOCATION. Tank truck or tank car receiving facilities should be located not closer than 100 feet from existing buildings, aboveground storage tanks, or public roads.

3. DESIGN REQUIREMENTS. The design of tank truck or tank car unloading facilities shall include the following equipment and design features:

a. Number of Positions. The number of unloading positions shall be adequate to unload the daily requirements of the facility in an 8-hour period.

b. Pumps. Where trucks or cars are unloaded into aboveground tanks, provide positive displacement or self priming centrifugal pumps, one for each truck or car that is to be unloaded simultaneously, at an average capacity of 300 gal/min. Where pumps are required for unloading aviation fuel, provide at least two pumps. Where trucks or cars are to be unloaded into underground tanks, pumps will not normally be required.

c. Hoses. Provide unloading hose, hose storage racks, and two 3-inch unloading connections for each unloading position.

d. Fuel Segregation. Provide separate unloading connections for each type of fuel to be handled.

e. Drainage. At each unloading position, provide a controlled drainage system leading to a containment or treatment system with sufficient capacity to

contain the contents of the largest fuel compartment of any tank truck and tank car that is to be unloaded.

f. General Arrangement. For unloading tank trucks, arrange the flow of traffic to permit continuous forward movement of trucks at all times. For unloading tank cars, provide a sufficient number of connections to permit unloading of one day's supply of fuel without moving the cars.

The basic layout shall be in accordance with NAVFAC P-272, Drawing No. 1403988, Unloading Facilities for Tank Trucks and Tank Cars, and shall also meet the minimum requirements of NFPA 30, Flammable and Combustible Liquid Code.

g. Electrical Design. The electrical design shall meet the minimum requirements of NFPA 70, The National Electric Code, NFPA 77, Recommended Practice on Static Electricity and NFPA 78, Lightning Protection Code.

h. Vapor Recovery. In air pollution protection basins, as established by law, provide an acceptable means to prevent the discharge of vapors from volatile petroleum fuels into the atmosphere when unloading a tank truck or tank car.

CHAPTER 3. DISPENSING FACILITIES

Fuel dispensing facilities are required for bulk issues of fuel to ships, boats, aircraft, cars, trucks, and other fuel consumers or transportation facilities. Minimum flow rates for dispensing facilities should be in accordance with Table 2. General design requirements for fuel dispensing facilities should be in accordance with Chapter 1.

Meters should be provided at all fuel dispensing points to monitor fuel quantities.

Section 1. MARINE FUELING AND DISPENSING FACILITIES

1. FUNCTION. Marine fueling and shipping facilities should be designed for the purpose of loading fuel aboard ships and boats for consumption or as cargo for shipment to another bulk storage plant. In many cases, the marine dispensing facility will be combined with a marine receiving facility.

2. FUEL PIERS AND WHARVES. Fuel piers and wharves for dispensing fuel shall be designed and equipped as described in Chapter 2, Section 1, Marine Receiving Facilities, with the addition that fuel outlets must be provided at intervals and in numbers appropriate for the number, type and size of vessel to be fueled or loaded at any given time. NAVFACENGCOM HQ will specify the type and number of vessel to be fueled or loaded.

The design should also include a meter for each fuel outlet that might be used simultaneously. Portable meters may be used where fueling operations are intermittent.

3. BERTHING PIERS. In some cases, permanent fuel piping and equipment may be installed on berthing piers which were not primarily designed for handling fuel. The design of such piers would be in accordance with NAVFAC DM-25, Waterfront Operational Facilities.

The design of fuel piping and equipment should be as described in the preceding paragraph and in Chapter 2, Section 1 as applicable.

4. OFFSHORE MOORINGS. Some activities which are designed for limited or temporary fueling or shipping operations may be designed with offshore moorings for fueling or loading the receiving vessel. In such cases, the offshore facilities should be designed as described for a receiving facility in Chapter 2, Section 1 with the addition of an on-shore pumping station and meters.

Section 2. INTERTERMINAL PIPELINES

1. FUNCTION. Large volume naval bulk fuel storage facilities may ship to other facilities by cross country interterminal pipelines. The pipeline may be a dedicated line connecting two or more facilities or it may be a privately owned common carrier line serving a number of commercial or military shippers.

The U.S. Department of Transportation regulates the design construction and operation of interterminal pipelines for liquid petroleum. Requirements are given in 49 CFR, Part 195.

In some cases, the shipping facility may consist of a relatively short spur which delivers the fuel to the suction side of a pumping station which is part of the main line of a larger pipeline system.

2. **DESIGN REQUIREMENTS.** The design of interterminal pipeline shipping facilities shall include the following features and equipment.

a. **Fuel Segregation.** Clean products, that is, gasoline, jet fuels, diesel fuel, and distillate type burner fuels may be shipped in the same system without segregation except that fuels must be dispatched in batches of the same type. Batches can be separated by pipeline balls or pigs. Residual fuels should not be shipped in the same system with the clean fuels described.

b. **Pumping Station.** The design must include a pumping station with sufficient head and capacity for the demand of the system. Pumps shall be in accordance with Chapter 1, Section 3.

c. **Controls.** Provide controls in accordance with Chapter 1, Section 5.

d. **Meters.** Provide turbine type meters with strainers and connections for proving the meter in accordance with Chapter 1, Section 2, paragraph 3.

e. **Sampling.** Provide means for taking samples of the products shipped.

f. **Scrapers.** Provide scrapers or pigs and a facility for launching them into the pipeline.

g. **Corrosion Protection.** Underground pipelines should be wrapped, coated, and cathodically protected.

h. **Antistatic Design.** Make full provision for antistatic design as recommended by NFPA 70, NFPA 77, NFPA 78, and API RP 2003.

Section 3. TANK TRUCK AND TANK CAR LOADING FACILITIES

1. **FUNCTION.** This section refers to facilities that may be required for loading over-the-road tank truck transports or rail cars which may be employed for bulk transfer of fuel. Bottom loading is required for all POL truck loading racks at activities engaged in retail or ready issue POL operations for reasons of safety, manpower savings, quality control of product, and area cleanliness.

Transfer by truck from a storage terminal to secondary storage such as a filling station or a heating plant by truck would be typical of such an operation. This section does not include facilities for loading fuel on aviation refuelers for direct issue to aircraft. The latter operation requires special design considerations which are discussed in the following Section 4.

2. TANK TRUCK LOADING FACILITIES.

a. Design Requirements. Facilities for fuel issue or transfer by tank truck shall be provided when required. The volume of fuel and number of trucks to be handled by the facility will be determined by an operational analysis.

When tank truck loading racks are required, the design shall include the following considerations, features and equipment:

(1) Static design shall be in accordance with NFPA 70, 77, 78, API Bulletin 1003, and API RP 2003.

(2) Tank truck loading racks shall be located at least 100 feet from the nearest aboveground tank, building, public road, or other fuel loading or dispensing facility. Where the activity is served by rail, it is preferred that the truck loading facility be located in the vicinity of, but not closer than 100 feet from, an existing rail siding.

(3) The loading rack shall consist of a row of parallel islands with sufficient clearance between to allow easy access to all parts of the trucks when parked. The islands and approaches shall be arranged in a manner that allows forward motion for all trucks at all times with ample room for turning.

Bottom loading islands shall be spaced and arranged to accommodate one truck only on the side facing the truck's liquid connections, usually the right side of the truck.

(4) The spaces between islands, and on each side of the outer islands, shall be paved with concrete and pitched a minimum of 1/8 inch per foot toward catch basins or trench drains. The catch basin shall be connected to a containment or drainage treatment facility with sufficient capacity to retain a fuel spill equal to the capacity of the largest fuel compartment of any truck to be loaded. The containment or treatment facility must also be able to contain the runoff from a rainfall of intensity equal to 5-year expectancy for a storm at the particular location. The containment may be combined with containments or treatment facilities of other areas.

If the loading rack is protected by a fire water or foam system, the drainage system should be designed with sufficient capacity to remove the entire discharge volume of that system as it is applied.

(5) In severe climates when authorized by NAVFACENGCOM, the loading rack may be protected by a weather cover of a design appropriate for the severe weather conditions. If the protective structure is included in the design, the underside of the roof shall be high enough so that operators can walk on top of the trucks without danger of striking their heads. Structural design shall be in accordance with NAVFAC DM-2, Structural Engineering.

(6) Each different type or grade of fuel shall have separate piping, pumps, loading connections, and controls. Each fill connection shall have an individual block valve.

(7) Each truck fill connection shall be metered. Each meter shall be protected by a strainer, an air release device, and a flow control valve. Two-stage set-stop controls, driven by the meter, are required.

(8) Each fill position shall have a deadman type switch with pilot light to control the flow to each loading connection in that position.

(9) Each fill position shall have provisions to start and stop the pump.

(10) Each fill position shall be equipped for trucks with high level shutoff switches. This shall include an electronic ground detector connected to an electrically controlled block valve or pump in such a manner that the valve cannot open or the pump cannot start if the truck compartment is full or the truck is not grounded.

(11) All piping shall be in accordance with Chapter 1.

(12) All truck loading racks shall have sufficient lighting to permit full visibility of all equipment and controls during night operations.

(13) Liquid concentrations to tank trucks for bottom loading shall be equipped with drybreak couplers in accordance with API RP 1004, Bottom Loading and Vapor Recovery for MC-306 Tank Motor Vehicles.

(14) All electrical systems and apparatus shall be classified for use in Class 1, Group D hazardous areas, regardless of the type of fuel dispensed.

(15) Consideration shall be given to protection of the facility against fire by an automatic foam system designed to protect the personnel, loading equipment, tank trucks, and adjacent facilities.

(16) Where volatile fuels are to be loaded and where required by local, State, or Federal law, the facility shall include a vapor collection and recovery or disposal system.

(17) Where viscous fuels are to be loaded, provide heaters and tracers as required to maintain the temperature of fuel at optimum pumping temperature.

3. TANK CAR LOADING FACILITIES. Facilities for fuel issue or transfer by railroad tank car shall be provided when required. In any case, the possibility of a future requirement for loading tank cars should be considered when designing a new facility. The volume of fuel and number of cars to be accommodated by the facility will be determined by an operational analysis.

When a tank car loading facility is required, the design shall include the following considerations, features, and equipment:

a. General Requirements. The design shall be in accordance with NAV-FAC P-272, Drawing No. 1403989, Tank Car Loading Facility, with provision for bottom loading where required.

b. Static Design. Static design shall be in accordance with NFPA 70, 77, 78, API Bulletin 1003, and API RP 2003.

c. Location. Tank car loading racks shall be at least 100 feet from the nearest aboveground storage tank, building, public road, or other fuel loading or dispensing facility. When appropriate, tank car loading and unloading facilities may be situated in the same location.

d. Platforms. A typical tank car loading rack shall consist of an elevated steel platform, consisting of a walkway, 4 feet wide, 10 feet 6 inches above the top of the rails, and the full length of six tank cars. The centerline of the structure shall be 10 feet 6 inches from the centerline of the tracks.

The platform shall be equipped with a counterweighted or spring loaded tilting bridge to connect to the tank car dome at each loading station. Design shall be such that, when released from the horizontal position, the bridge will automatically move to and lock in an upright position out of the way of any part of the car under all conditions of wind, ice, snow, etc.

Structural design shall be in accordance with NAVFAC DM-2, Structural Engineering.

e. Drainage. An area extending from 5 feet outside of each outer rail, completely under the loading platforms and extending longitudinally 15 feet each way from the center of each loading position shall be paved with concrete. The paved area shall be sloped for drainage and catchment or treatment facility as described for tank truck loading racks in the preceding paragraph 2.a.(4).

f. Loading Connections. Loading connections, controls, valves, etc., shall be provided on one side or both sides of the loading platform as specified by NAVFACENGCOM HQ. Tank cars shall be loaded from the top using counterbalanced, articulated tank car loading assemblies. Splash loading of gasoline or distillate type fuels will not be permitted. Drop tubes used for top loading shall be long enough to reach the bottom of the car tank. Loading valves shall be self closing.

g. Weather Sheds. Where extreme climatic conditions prevail, tank car loading racks may be provided with weather sheds when specified by NAVFAC-ENGCOM HQ. Clearances shall be sufficient to permit the passage of cars and locomotives and clear operation of loading equipment.

h. Fuel Segregation. Each different type or grade of fuel shall have separate piping, pumps, loading connections, and controls. Each loading connection shall have an individual block valve.

i. Meters. Each tank car loading connection shall be metered. Each meter shall be protected by a strainer, a flow control valve, and an air release device.

j. Controls. Each loading position shall have a pushbutton with pilot light to control the pump for each loading connection in that position.

k. Grounding and Bonding. The rails of tank car sidings shall be electrically insulated from connecting spur tracks. The insulated rails, and loading rack structure, and piping shall be connected to a common ground bed or rod. Before loading, the tank car shall be connected to the common ground by a grounding clamp and cable as shown in NAVFAC MO-230, Maintenance Manual, Petroleum Fuel Facilities, Figure 127.

l. Piping. All piping shall be in accordance with Chapter 1.

m. Lighting. When specified, tank car loading racks shall have sufficient lighting to permit safe night operation.

n. Electrical Classification. All electrical systems and apparatus within 15 feet, measured horizontally, and 5 feet upward and downward to the ground from the car dome, shall be classified for use in Class 1, Group D hazardous areas.

o. Vapor Recovery. Where volatile fuels are to be loaded and where required by local, State, or Federal law, the facility shall include a vapor collection and recovery or disposal system.

Where viscous fuels are to be loaded, provide heaters and tracers as required to maintain the fuel temperature at optimum pumping temperature.

Section 4. AIRCRAFT FUELING FACILITIES

1. FUNCTION. Aircraft fueling facilities as discussed in this section, are designed for fueling of shore based aircraft including both fixed wing and helicopter types. The preferred method of fueling which shall be employed at most facilities is by refueler tank trucks. Aircraft direct fueling systems where fuel is delivered directly to the aircraft through underground piping systems may be required to meet the operational demands of a few air stations. Aircraft direct fueling systems shall be installed only when specifically authorized by NAVFACENGCNOM HQ in conjunction with NAVAIR HQ. The fuels to be used by aircraft and covered in this section may include one or more grades of jet fuel and aviation gasoline. Because of the critical nature of the end use of the fuel, protection of fuel quality, safety, and dependability of the system are especially important.

2. DESIGN REQUIREMENTS.

a. General Requirements.

(1) Provide a separate piping system for each grade of fuel to be handled. Do not provide cross connections between grades.

(2) Each aviation fueling system shall have at least two pumps in accordance with Chapter 1, Section 3. Pumps for any single grade of fuel shall be connected in parallel.

(3) Only corrosion resistant pipe such as aluminum, stainless steel, or fiber reinforced plastic (FRP) shall be used for aviation fueling systems from the operating storage tank outlet to the last fuel discharge

point including the return or circulating lines back to the storage tanks or filter/separators. Zinc, copper, and zinc or copper bearing alloys shall not be used in contact with aviation fuels.

(4) Unless otherwise specified by NAVFACENGCOM HQ, piping systems in and around areas subject to aircraft ground movements shall be underground. Fueling equipment may be aboveground where it does not interfere with aircraft or service vehicle movements. Horizontal and vertical clearances shall be in accordance with NAVFAC DM-21, Aircraft Pavements.

(5) Metallic underground piping shall be protected against exterior corrosion by wrapping, coating, and cathodic protection as described in Chapter 6.

(6) Each fuel outlet shall be metered.

(7) Other basic piping design, fittings, valves, and accessories shall be in accordance with Chapter 1, Section 2.

Pumps shall be controlled by a manual pushbutton to start the first pump and automatic flow sensing devices to cause subsequent pumps to start on demand. The system shall include a variable selector to change the sequence of starting.

The system shall include an emergency shutoff switch at each fueling station.

Other control design features shall be in accordance with Chapter 1, Section 5.

(8) At each fuel dispensing station, provide electric power for operation of control valves, other control devices, and lighting.

(9) Antistatic design shall be in accordance with Chapter 1, Section 6.

b. Refueler Truck Fill Stands.

(1) NAVFACENGCOM HQ, in conjunction with NAVAIR HQ, will specify the number of grades of fuel to be handled and the number of refueler loading stations required for each facility.

(2) The design shall be in accordance with NAVFAC Drawing No. 1403987, Aircraft Refueler Truck Fill Stand.

(3) Provide a separate loading system for each grade or type of fuel to be handled.

(4) The refueler loading facility shall be located as close as practical or permissible to the location of the aircraft to be fueled but not less than 100 feet from the nearest aboveground storage tank, building, or public road.

(5) If the facility has an aircraft direct fueling system, the fuel supply piping to the refueler truck loading facility may be a spur or extension from that system. In such case, the filter/separator and fuel quality monitor indicated in equipment items (9)(f) and (9)(g), following, would not be required since they are provided as part of the aircraft direct fueling system.

(6) Aircraft refueler trucks shall be loaded by bottom loading only. Top loading will not be permitted.

(7) Fuel loading equipment shall be arranged on one or more concrete islands arranged for fueling on one side only. The direction of traffic shall be appropriate for the location of the loading connections on the refueler, usually the curb or right side. More than one island may be required by the volume or number of fuel grades to be handled. When more than one island is required, they shall be arranged in a parallel fashion approximately 15 feet between adjacent sides. The islands and approaches shall be arranged in a manner that allows forward motion for all trucks at all times with ample room for turning.

(8) The spaces between islands and on the loading side of the end island shall be paved with concrete and pitched a minimum of 1/8 inch per foot toward catch basins or trench drains. The catch basins shall be connected to a containment or drainage treatment facility with sufficient capacity to retain a fuel spill equal to the volume of the largest compartment of any refueler to be loaded. The containment or treatment facility must also be able to contain the runoff from a rainfall of intensity equal to a 5-year expectancy for a storm at the particular location. The containment may be combined with containments or treatment facilities for other areas.

(9) Each refueler truck fill stand shall include the following equipment:

(a) Dry-break fueling nozzle of size and type compatible with truck loading connections, coded for product use.

(b) Loading hose, approximately 10 feet long, of nominal size equal to the meter size.

(c) Diaphragm operated two stage control valve electrically controlled by a set-stop register on the meter. The control valve shall also include the following operational features:

Adjustable rate of flow control.

Adjustable time delay to prevent the high flow pilot from opening for 1 minute after start of flow.

Main valve to close in the event of diaphragm failure.

Thermal pressure relief.

Manual override of pilot system.

Position indicator.

(d) Relaxation tank or piping configuration with sufficient capacity to retain the maximum flow of the loading station for 30 seconds.

(e) Temperature compensated positive displacement meter with rated capacity equal to the maximum flow of the loading station and the following accessories:

Two stage, large numeral, pushbutton, set stop register with two double pole, double throw switches.

Consider the use of combination ticket printer and large numeral zero reset counter with self closing weatherproof cover.

Pulse transmitter of the wetted reed switch type (optional for system employing electronic data acquisition systems).

(f) Filter/separator.

(g) Fuel quality monitor.

(h) Shutoff valves for service equipment.

(i) Sample outlet.

(j) A high level cutoff system which incorporates, with a single cable connection to the refueler, self monitoring automatic tank fill shutoff device, bonding, grounding, and deadman control.

(k) All piping shall be in accordance with paragraph 2a. of this Section.

(l) Provide low intensity instrument lighting to permit full visibility of all equipment and controls during night operations.

(m) All systems and apparatus shall be classified for use in Class 1, Group D hazardous areas, regardless of the type of fuel dispensed.

(n) Where avgas or JP-4 are to be loaded, and where required by local, State, or Federal law, provide a vapor collection and recovery or disposal system.

c. Aircraft Direct Fueling Systems.

(1) Aircraft direct fueling systems shall be installed only when specifically authorized by NAVFACENGCOM HQ and NAVAIR HQ. The two Commands shall jointly determine the number and type of aircraft direct fueling stations required by the activity. New aircraft direct fueling facilities shall be constructed only for the issuance of jet fuels through the closed circuit method utilizing underwing aircraft servicing nozzles to dispense the product. Criteria for the construction of direct fueling systems will be the volume of rapid turnaround requirements for carrier aircraft, including rotary wing, the volume of large land based patrol aircraft requiring average refueling of over 2500 gallons and numbers of transport aircraft, with limited ground time, which must be refueled in place simultaneously with other loading and offloading

functions. Carrier aircraft may be "hot" fueled with engines idling; large patrol aircraft may be fueled either with engines idling or auxiliary power units running; transport aircraft will be refueled in static condition.

For typical arrangements of aircraft direct fueling systems, see the following definitive drawings:

(a) NAVFAC Drawing No. 1403985, Aircraft Direct Fueling System, Flow Diagram.

(b) NAVFAC Drawing No. 1403986, Aircraft Direct Fueling System, Typical Fueling Station.

(c) NAVFAC Drawing No. 1403987, Aircraft Refueler Truck Fill Stand.

(2) Aircraft direct fueling stations for mission oriented fueling of carrier type aircraft with engines running and patrol aircraft will be located along the edge of access ramps, aprons, or fueling lanes situated for easy access by the aircraft as near as practical to their normal taxi routes. Taxi patterns to and from fueling stations should preclude aircraft jet blast on ground personnel.

Each aircraft direct fueling station shall include block valves, fusible link shutoff valves, positive displacement meter, pressure control valve, venturi, 4-inch pantograph, emergency break-away coupling, 3-inch hose, hose-end regulator, dry-break quick-disconnect coupling with 60 mesh strainer, fuel nozzle, deadman control, nozzle stowage fitting on the circulating return line and recirculation control valve. The schematic arrangement of this equipment is shown on NAVFAC No. 1403986, Aircraft Direct Fueling System, Typical Direct Fueling Station.

Outside of the limits prescribed for clear areas by DM-21, Aircraft Pavements, the equipment described shall be located aboveground on a concrete slab adjacent to the edge of an access ramp, apron, or fueling lane. The width of the slab and location of the equipment, including the pantograph when retracted, with respect to the ramp, apron, or fueling lane, shall be such that the equipment will not interfere with any part of the aircraft on its approach to or departure from the fueling station.

The maximum height of equipment, including lighting, on the slab shall not exceed 36 inches above the elevation of the concrete pad.

The maximum flow rate for each direct fueling station shall be 600 gal/min. The maximum allowable pressure at the skin of the aircraft shall be 50 psi, plus or minus 5 psi.

NAVFAC Drawing No. 1403985, Aircraft Direct Fueling System, Flow Diagram, shows a typical arrangement for fueling aircraft. The minimum sized system for carrier type aircraft shall be 1,200 gal/min. with at least two fueling stations. Where more than two fueling stations are required, the combined system rate shall be increased by 600 gal/min. for every three additional fueling stations.

(3) Large aircraft such as transports, cargo planes, and ready alert long range patrol planes may also be fueled from direct fueling stations located adjacent to their normal parking positions. The system required is generally identical to that described in paragraph 2c(2) but differs in the location of the fueling station and the length of the pantograph. Because of their physical size and the large amount of ground service and support required, large aircraft are parked on parking aprons away from active flight areas for refueling and other necessary ground services. Direct fueling stations are located adjacent to the parking areas so that the aircraft can be refueled while other concurrent services are being performed.

The number of fueling stations required must be individually determined for each activity, based upon the number of large aircraft based at the activity or the number that might have to be refueled as transients at any given time. In order to accommodate the requirement for fueling a number of aircraft within a given time span without moving them, normally more fueling stations are required than would actually be used at one time.

Flow rate criteria for fueling large aircraft shall be 600 gal/min. for each three fueling stations, and each fueling station shall be capable of delivering 600 gal/min. This arrangement shall be considered in addition to fueling stations for carrier type aircraft. Combined system requirements shall be sized in multiples of 600 gal/min. starting at a minimum flow rate of 1,200 gal/min. and going up to a maximum flow rate of 4,800 gal/min.

The piping design, hydraulics, materials, and pumps for an aircraft direct refueling system shall be in accordance with paragraph 2a. of this Section.

Fueling systems for transport type and carrier type aircraft may be designed with common pumps and connecting piping as suggested by NAVFAC Drawing No. 1403985, Aircraft Direct Fueling System, Flow Diagram.

(4) Large aircraft such as transports and cargo planes may also be fueled from flush type hydrants. This type of system should only be used in those cases where normal aircraft parking positions cannot be located so that the aircraft can be reached by pantograph fueling stations, which are preferred. Where flush hydrants are required, the design shall conform to Department of the Air Force Drawing No. AW 78-24-28 and Specification 78-24-28-72-AF, Air Force Standards, Pressurized Hydrant Fueling Systems. This design requires the use of self propelled hydrant hose trucks or detachable pantograph assembly to provide the connection from the flush type hydrants to the aircraft and the necessary controls. Hydrant trucks shall conform to the requirements of MIL-T-83973, Truck Hydrant Hose. When detachable pantographs are used in lieu of hydrant hose trucks, the hydrant control valve must be hydraulically actuated. Pantographs shall be complete with hydrant coupler, flow meter, hose end regulator, fueling nozzle, hydraulic deadman control, pressure relief cock and other necessary appurtenances.

(5) Direct fueling systems as previously described for other types of aircraft may also be used to fuel helicopters.

The basic design of piping pumps, controls, accessory, and auxiliary systems shall be in accordance with paragraph 2a. of this Section, except that the flow rate for helicopters shall be 300 gal/min. The minimum size system shall be 600 gal/min. with at least two fueling stations. Increase by 300 gal/min. for every three additional fueling stations.

Direct fueling stations for helicopters shall be aboveground and equipped the same as those described for carrier type aircraft, except that the fueling stations shall be located adjacent to the edge of the apron. The horizontal position and vertical projection of fueling equipment shall be designed to avoid interference with the helicopters' blades when in the drooped attitude.

d. Defueling Systems. Defueling of aircraft shall be accomplished by the use of tank vehicles.

e. Avgas Fueling Systems. Aircraft requiring avgas shall be fueled by truck. Refueler loading stands for avgas shall be designed in accordance with the criteria for jet fuel.

3. FILTER/SEPARATORS AND FUEL QUALITY MONITORS.

a. Function. Because of the very high quality requirements for aviation fuels, special precautions are required to remove dirt and moisture from the fuel. Aviation fuel which contains more than 2 milligrams per liter of solid contaminants such as rust or dirt particles, or more than 5 parts per million of free moisture, are not acceptable for use in aircraft. Filter/separators are installed in aviation fuel systems to remove such contaminants. To further insure fuel cleanliness, fuel quality monitors are required downstream of filter/separators.

Fuel quality monitors downstream of dispensing filter/separators shall be cartridge type monitors designed to gradually stop the flow of fuel when the accumulated amount of contaminating dirt or water causes a significant increase in differential pressure. Fuel quality monitors downstream of receiving filter/separators shall be turbidity type monitors which scan the turbidity of the fuel and are capable of generating an electrical signal which can be translated into a readout or control an electrical device (such as a remote operated valve) to stop the flow of contaminated fuel.

b. Design Requirements. Application and design of filter/separators for aviation fuel systems shall be as follows:

(1) Design details, specifications, and accessory equipment for filter/separators shall be in accordance with Chapter 1, Section 2, paragraph 3. (For additional details, see NAVFAC MO-230, Maintenance Manual - Petroleum Fuel Facilities, Section 2.5.1.)

(2) Design details and specifications for fuel quality monitors of the cartridge type, shall be in accordance with Chapter 1, Section 2, paragraph 3g. (For additional details, see NAVFAC MO-230, Section 2.5.1.)

(3) In aviation fuel systems, install filter/separators in the following locations:

(a) In the incoming fuel supply system upstream of and adjacent to all operating storage tanks.

Provide a minimum of two filter/separators connected in parallel at these locations. Where the fuel is transported by pipeline, tanker or barge, provide hydrocyclonic or other solid separators in the receiving line ahead of the filter/separators. Filter/separators used in the incoming fuel supply system shall have combined capacity sufficient to take the full discharge rate of the supply system.

Arrange the system piping so that fuel from the discharge side of the fueling system transfer pumps can be recirculated back through the inlet filter/separators into the operating storage tank.

Inlet filter/separators may serve more than one operating storage tank.

(b) At each aviation refueler truck fill stand.

(c) In aircraft direct fueling systems on the downstream side of operating storage tanks. Arrange the piping so that the fuel can be circulated from the operating storage tanks, through the filter/separators, to each aircraft fixed fueling station and back through the inlet filter/separators to the operating storage tanks. These dispensing filter/separators shall be of the same number and capacity as the transfer pumps, that is; for three 600 gal/min. pumps, provide three 600 gal/min. filter separators. (See NAVFAC Drawing No. 1403985, Flow Diagram, Aircraft Direct Fueling System, for the general arrangement required.)

(4) In aviation fuel systems, install fuel quality monitors downstream of all filter/separators.

(a) Use turbidity type monitors in storage tank inlet piping.

(b) Use cartridge type monitors in storage tank outlet piping, including piping serving aircraft direct fueling stations or refueler truck fill stands.

(5) Where practical, arrange piping downstream of filter/separators and fuel quality monitors so that the piping will provide 30 seconds retention time before the fuel is dispensed or enters a storage tank. Where this is not possible, relaxation tanks are required.

4. CONTAMINATED FUEL STORAGE TANKS.

a. Function. In addition to regular storage, tanks for aviation fuel storage must be provided for fuel removed from aircraft which is contaminated or otherwise not satisfactory for its intended use.

b. Design Requirements. The volume of the contaminated fuel storage tank required shall be determined by a station survey. Provide a contaminated fuel storage tank for each major grade of aviation fuel handled at the facility.

The tanks shall be located in or near the station tank farm. Tanks shall be clearly marked as to the type or grade of fuel.

Provide bottom loading facilities for tank truck loading and unloading of contaminated fuel.

5. AVIATION LUBE OIL STORAGE TANKS. Because of the decline of reciprocating engine aircraft and the use of packaged lubricating oil products for jet aircraft, no bulk lubricating oil storage facilities are required and no criteria are provided.

Section 5. AUTOMOTIVE FILLING STATIONS

1. FUNCTION. Gasoline filling stations are required to dispense fuel to motor vehicles. The fuel may be either motor gasoline or diesel fuel.

2. DESIGN REQUIREMENTS.

a. General Requirements. Provide separate facilities for government owned and private vehicles. Provide separate storage and dispensing facilities for each grade or type of fuel to be dispensed.

(1) In each filling station for government vehicles, provide one noncomputing commercial type dispensing unit for each 100 vehicles assigned to the activity. The total amount of storage capacity in each station should be approximately twice the capacity of all vehicle fuel tanks, by grade or type of fuel, assigned to the activity. Minimum storage capacity for any grade or type of fuel shall be 5,000 gallons.

(2) In private vehicle filling stations, provide one fuel island for each 1,500 vehicles to be serviced, with a computing type service station dispenser for each grade or type of fuel. Number and size of fuel tanks shall be determined by survey of fuel demand. Minimum size storage for any grade or type of fuel shall be 5,000 gallons.

(3) For manned facilities, provide a shelter for personnel, records, and tools.

(4) Piping and equipment shall be in accordance with Chapter 1 of this manual and NFPA 30, Flammable and Combustible Liquids Code. Typical installation layouts can be seen in API Bulletin 1615, Installation of Underground Gasoline Tanks and Piping at Service Stations.

b. Storage Tanks. Fuel shall be stored in underground, horizontal, cylindrical tanks. Where past experience or estimates of soil corrosiveness indicates that coal tar coated steel tanks will not last more than 15 years, use fiberglass reinforced plastic (FRP) tanks or FRP coated steel tanks. Tanks and piping shall be in accordance with NFGS, Fuel Oil Handling Systems.

c. Fuel Dispensers. Fuel dispensers may be the commercially available type with a self-contained electric motor and pumping unit or the remote pumping type where the pump and motor are located in the storage tank. Each

dispenser shall be metered. Flow rates for passenger vehicles shall be approximately 10 gal/min. Flow rates for trucks and buses shall be approximately 25 gal/min.

d. Card and Key Locks. The design shall consider the possible economic and operational advantages of using an electronic card or key system which permits 24 hour unmanned operation of the facility and records each fuel user and the quantities taken by each.

e. Electrical Design. Electrical systems shall be in accordance with NFPA 70, National Electric Code.

f. Drainage. Fueling islands shall be surrounded by a concrete slab pitched 1/8 inch per foot towards a drainage inlet connected to a contaminant or treatment facility capable of containing or treating any spills which may occur.

g. Vapor Recovery. In all gasoline dispensing facilities, provide vapor return piping from the dispensers to the fuel tanks and from the fuel tanks' vent connections to a point where they can be conveniently connected to delivery tank trucks by hose.

In gasoline dispensing facilities located in air pollution protection basins, as established by law, install vapor return lines and, if required, a vapor recovery or disposal unit that meets the air quality requirements of the law in effect in the particular area.

CHAPTER 4. FUEL STORAGE TANKS

Section 1. DESIGN CRITERIA

1. SCOPE. This chapter contains general and technical design criteria for naval shore facilities storing liquid fuel.

2. RELATED CRITERIA. For additional criteria on liquid fuel storage and related systems, see the following chapters in this manual:

<u>Subject</u>	<u>Source</u>
Basic Requirements	Chapter 1
Receiving Facilities	Chapter 2
Dispensing Facilities	Chapter 3
Corrosion Protection	Chapter 6
Fire Protection	Chapter 7
Protection of the Environment	Chapter 8

3. POLICY. The design of liquid fuel storage tanks shall satisfy the operational requirements of the particular command having jurisdiction in the area of the facility and shall be appropriate for the mission of the facility. The design shall also comply with the operational requirements of the users of the fuel (e.g., storage tanks for aviation fuel must be capable of delivering fuel of suitable quality for use in aircraft.)

4. DESIGN REQUIREMENTS. Fuel storage facilities are intended to provide an operating and reserve supply of fuel. The types and sizes of storage tanks are determined by considerations of safety, economics, locality, and intended service. The selection and design of storage tanks shall also give consideration to the following factors:

a. General Requirements. The products to be stored must be protected to preserve product quality and to ensure minimum losses by evaporation, dilution, leakage, substitution, theft, contamination, attack, sabotage, fire, and protection of the environment. Aboveground steel tanks are preferred, but when required by the mission of the activity or other practical considerations, underground tanks may be used.

b. Interior Coatings. In order to protect product quality and to extend the life of the tank, the following prescribed interior surfaces of all steel storage tanks shall be coated in accordance with NFGS-09872, Interior Coating Systems Used on Welded-Steel Tanks (for Petroleum Fuel Storage).

(1) For all aviation fuel storage tanks at Naval Air Installations, coat the entire interior including piping and appurtenances.

(2) For all aviation fuel storage tanks at bulk fuel terminals, coat the bottom and up 18 inches onto the tank shell.

(3) For all ground fuel storage tanks over 20,000 gallons capacity at all locations, coat the tank bottom and up 18 inches onto the tank shell.

(4) For existing concrete tanks that have a record of leakage, the interior bottom and walls shall be lined in accordance with NAVFAC TS-09871, Lining System, Interior, for Concrete Storage Tanks (for Petroleum Fuels).

c. Exterior Coatings. The entire exterior coating of aboveground steel storage tanks, except the underside of bottom plates, shall be coated in accordance with NAVFAC TS-09873, Exterior Coating System for Welded Steel Storage Tanks Used in Petroleum Service.

d. Fuel Segregation. Provide separate storage for each type or grade of fuel.

e. Location and Arrangement. Tank farm location and arrangement should consider the following factors:

(1) A site on gently rolling terrain, or location above the facility to be served, is preferred for both aboveground and underground storage.

(2) For dispersion and concealment, stagger tank spacing as much as possible to minimize alinement. In large installations, separate the tanks into two or more subgroups.

(3) In general, use aboveground steel tanks for bulk storage. Where military or safety considerations govern, tanks may be placed underground. Where tanks storing high volatile fuels will be close to buildings or other structures, locate them underground to minimize fire hazards. Clearance criteria shall conform to Chapter 4, Section 1, paragraphs 6, 7 and 8.

f. Floating Roofs. The basic configuration for field-erected bulk storage tanks should be a vertical cone roof tank. When the tank is to be used for the storage of fuel with a true vapor pressure of 1.5 psia or more, such as gasoline at any storage temperature or JP-4 where the fuel temperature exceeds 70° F; the cone roof tank should be equipped with an internal floating pan. For very large bulk tanks for volatile fuels, consideration should be given to the use of open top, double deck floating roof tanks.

g. Tank Bottom Connections, All Tanks. Provide adequate sumps, drain lines, and water drawoff lines in every fuel storage tank. The bottoms of vertical tanks should be shaped as an inverted cone sloping down from the shell to the center at a uniform 1:20 slope with a sump at the center.

Water bottoms of aviation fuel tanks will be controlled by circulating fuel with the main pumps through filter/separators which will remove any entrained water or particulate matter. These are called circulating tanks. In this arrangement, the water drawoff becomes a secondary device that may seldom be used. Noncirculating tanks, which are normally used for other than aviation fuels, will depend more heavily on the use of the water drawoff connection. The water drawoff valve or pump connection from each, or when feasible from several of these tanks, should be connected to a filter/separator, product saver or oil/water separator. If a filter/separator is used, its capacity shall be at least ten times greater than the flow rate from the water drawoff or sump pump connection. To achieve this in tanks with 50 gal/min. sump pumps, it is necessary to throttle a discharge valve to limit the flow

rate to 10 gal/min. during circulation through the filter/separator. Provide suction, drain, and water drawoff lines for aboveground tanks as follows:

(1) A 1-inch water drawoff line from noncirculating tanks from a point 2 inches above the bottom of the sump to an antifreeze type water drawoff valve on the outside of the shell.

(2) A 6-inch low suction (2-inch at aviation activities) from a point 4 inches above the bottom of the sump to a gate valve on the outside of the shell which shall be connected to the main tank suction line with a tee and blind flange as shown in Figures 6 and 8. This connection will be used for bottom pumpout when required.

(3) For circulating tanks, locate the main suction 6 inches above the top of the sump. Provide an antivortex plate on the sump end of the line. (See Figures 6 and 7.)

(4) For noncirculating tanks, locate the main suction 12 inches above the tank floor and 24 inches inside the tank shell. (See Fig. 8.)

h. Tank Bottom Connections, Underground Tanks. Provide suction, drain, and water drawoff connections from underground tanks as follows:

(1) For water drawoff and tank bottom stripping from vertical circulating tanks, provide a 10 gal/min. vertical turbine pump with the bottom of the suction bell approximately 2 inches from the bottom of the sump, a filter/separator, with a minimum 100 gal/min. capacity, and a return line to the inlet line of the tanks. The pump shall be of a type that is suitable for continuous pumping of water and fuel mixtures. (See Fig. 11.)

(2) For vertical circulating tanks, provide vertical turbine transfer pump(s) of appropriate capacity, with the bottom of the suction bell 6 inches above the tank floor as close to the sump as possible. Provide an antivortex plate at the end of the suction bell. (See Fig. 11.)

(3) For vertical noncirculating tanks provide a vertical turbine transfer pump of appropriate capacity as described in (2) above with the bottom of the suction bell 12 inches above the tank floor (See Fig. 12) and a 50 gal/min. vertical turbine pump for water drawoff and bottom stripping.

(4) For water drawoff from horizontal underground tanks, provide a 3/4-inch connection from the low end of the tank to a point approximately 3 feet 6 inches above the ground and equipped with a positive displacement type hand operated pump or electrical pump.

i. Tank Gages. Provide an automatic tank gage for each tank with a conveniently located readout station. The gage shall be of the type that can be readily adapted for remote tank gaging. The remote tank gaging system shall be installed when appropriate.

In addition, each tank shall be equipped with a separate high level alarm, actuated by a float or displacer separate from the gaging mechanism and having two alarm points. One alarm point shall be at approximately 95 percent of capacity, and the second alarm point shall be at approximately 98 percent of

capacity. The high level alarm shall include both audio and visible alarms, and, may be connected to close valves or stop pumps when an alarm condition occurs.

5. **STORAGE CAPACITY.** The capacity or size of each fuel storage tank is based upon the logistic requirements for a fuel storage facility. Topographic and subsurface conditions also will influence tank size. For a stated volume of each fuel, fewer tanks of larger size will result in maximum economy. The number of tanks for each fuel shall be sufficient to receive and isolate new receipts until tested and checked for quality and quantity while the facility continues to function with stocks on hand. Tanks with circulation capability and metering can be used for simultaneous receipts and issues of fuel and eliminate the need for additional receipt tanks.

In general, capacities of individual tanks should approximate 25 percent of the total storage volume of each grade of fuel subject to the following:

Minimum capacity of a tank for fuel depot bulk storage shall be 13,500 barrels.

Maximum capacity for a storage tank shall be 100,000 barrels except when larger tanks are specifically authorized by NAVFACENGCOM HQ.

Provide a minimum of two tanks for each type of fuel. On an alternating schedule, one tank will be the working tank and the other tank will be the receiving tank for new deliveries.

The maximum capacity of horizontal storage tanks shall be 40,000 gallons each.

6. TANK SPACING.

a. Vertical Tanks. The minimum distance between the shells of vertical tanks, both aboveground and underground, should be not less than one diameter of the larger tank. Where it is necessary to arrange the tanks so that more than two are in a single row, the spacing should be increased to two diameters of the largest tank.

b. Horizontal Tanks. The minimum clearance between shells of adjacent horizontal underground tanks should be 3 feet and the minimum clearance between aboveground horizontal tanks with capacities 40,000 gallons or under should be as follows:

(1) Tanks should be arranged in pairs with a minimum of 5 feet between tanks in each pair and 10 feet between adjacent tanks of two pairs in the same row.

(2) Adjacent groups of more than two pairs in a single row should be spaced 20 feet between the nearest tanks of the groups.

(3) Minimum end-to-end spacing between tanks in longitudinal rows should be 20 feet.

7. TANK DISTANCE FROM BUILDINGS AND PROPERTY LINES.

a. Underground Tanks. Underground tanks should be located with respect to buildings or similar structures so that the soil pressure created by the building foundations will not be transmitted to the tank. Pumping facilities which are often located directly above underground tanks are excepted.

Horizontal cylindrical tanks not over 12 feet in diameter should be located not less than 10 feet from the nearest point of an adjacent building or property line except pumping facilities. Vertical underground tanks should be located at least 25 feet from the nearest point of an adjacent building and 50 feet from the nearest property line except pumping facilities.

b. Aboveground Tanks. The location of aboveground tanks with respect to buildings and property lines is governed by considerations of fire safety. The first consideration is to prevent the ignition of vapors from the tank. The second consideration is to protect the building and its occupants or contents from damage by a tank fire.

As a protective measure, all aboveground tanks are required to have some form of emergency relief venting for fire exposure in accordance with NFPA 30, Flammable and Combustible Liquids Code.

In the following, it is assumed that all tanks are constructed or equipped so that the maximum internal pressure in a fire exposure will not exceed 2.5 psi.

Recommended minimum distances for aboveground tanks from important buildings and property lines are as follows:

(1) Tanks, all sizes and types, containing petroleum fuels with a flash point less than 100° F, 100 feet or one tank diameter, whichever is greater.

(2) Tanks containing petroleum fuels with a flash point of 100° F or greater in accordance with the following:

Tank Capacity (gallons)	Minimum Distance from Property Line or Nearest Important Building (feet)
275 or less	5
276 to 750	10
751 to 12,000	15
12,001 to 30,000	20
30,001 to 50,000	60
50,001 to more	100

8. TANK DISTANCE FROM ROADWAYS, RAILROADS, AND POWER LINES. Minimum distances of storage tanks from adjacent roadways, railways, railroads, and electric power lines are as follows:

Regularly travelled roads and highways not including tank farm utility and fire roads, to underground tanks, 25 feet; to aboveground tanks, 100 feet or one diameter, whichever is greater.

Railroad spur tracks not used for through traffic, to underground tanks, 25 feet; to aboveground tanks, 50 feet.

Main railroad tracks carrying through traffic, to underground tanks 100 feet; to aboveground tanks, 200 feet.

Electric power transmission and distribution wires, to all types of tanks, 50 feet.

Section 2. HORIZONTAL STORAGE TANKS

1. DESIGN REQUIREMENTS.

a. Underground Tanks. Where underground storage tanks of limited capacity are required, shop-built horizontal cylindrical tanks should be used. The effects of underground corrosion, which are discussed in greater detail in Chapter 6, should be considered in selecting the material of construction. Because of their economy, welded steel tanks are preferred for installations where there is no indication of a severe corrosive condition. Where past experience or evaluation of soil corrosiveness indicates that steel tanks will not last more than 15 years, the use of steel tanks coated with fiber reinforced plastic (FRP) or FRP tanks up to 40,000 gallons capacity should be considered.

Welded steel tanks for underground service should be designed and constructed in accordance with Underwriter's Laboratories, Inc. (UL) Standard 58, Standard for Steel Underground Tanks for Flammable and Combustible Liquids, latest issue, and so labeled. Tank diameter for tanks without internal bracing shall not exceed 12 feet and the length shall not exceed six times the diameter.

FRP tanks shall be UL listed for the intended service and shall comply with MIL-T-52777, Tanks, Storage, Underground Glass Fiber Reinforced Plastic.

Tanks shall be installed in accordance with NFPA 30 and also in strict accordance with the manufacturer's installation instructions.

Underground tanks of either type shall include the following appurtenances, accessories, and equipment:

(1) Tanks of 1,000 to 12,000 gallons capacity shall have a 30-inch manhole and tanks over 12,000 gallons capacity shall have a 36-inch manhole. Extension necks and internal ladders are optional for larger tanks.

(2) Level gage calibrated in 1/8-inch graduations with aboveground readout at a convenient location.

(3) Gage hatch with stilling well to within 3 inches of the tank bottom.

(4) Submerged fill pipe extending to within 6 inches of the tank bottom and equipped with a means by which the operator can limit the inlet flow to 3 feet per second until the fill pipe is completely submerged.

(5) Provide internal heating coils or suction heaters for tanks intended for viscous product service such as No. 6 fuel oil.

(6) All underground storage tanks shall be equipped with atmospheric vents in accordance with NFPA 30, Flammable and Combustible Liquids Code. Vent piping shall slope downward toward the tank with a uniform slope of not less than 2 inches in 10 feet.

(7) Design the tank installation so that the bottom slopes downward toward one end at a slope of 1 to 60. For tanks connected to circulating systems, as required for aviation fuel systems, transfer pumps or suction piping shall be located at the low end of the tank.

For tanks connected to noncirculating systems, transfer pumps or suction piping shall be located at the high end of the tank.

(8) Provide a pumpout connection from the bottom of the low end of the tank to the surface. For large tanks in non-traffic areas, provide a hand- or electric-driven positive displacement sump pump approximately 3 feet 6 inches above the ground level.

(9) Provide straps and anchors designed to prevent flotation of tanks located in areas with high water tables or subject to flooding.

(10) Provide cathodic protection for steel tanks with special exterior coatings, except for tanks coated with FRP fiberglass reinforced plastic conforming to NAVFAC TS-15611, Fuel Oil Handling Systems.

(11) Place tanks on a uniform bed of homogeneous granular material at least 6 inches thick. Do not use blocks, chocks, or rocks and do not place tanks directly on concrete foundation pads if such are used.

b. Aboveground Horizontal Tanks. Where there is a requirement for small aboveground storage tanks which can be shop-built, they shall be not over 12 feet in diameter nor more than 40,000 gallons capacity. The tank should be of welded steel construction in accordance with UL Standard 142, Standard for Steel Aboveground Tanks for Flammable and Combustible Liquids.

When such tanks are required, the design shall include the following appurtenances, accessories, and equipment:

(1) A 30-inch manhole, for tanks up to 12,000 gallons and 36-inch manhole for tanks over 12,000 gallons.

(2) A ladder and platform for gaging and sampling.

(3) Tanks shall be mounted on reinforced concrete foundations or, if on steel supports, the steel shall be covered with a fireproof jacket of concrete or cement mortar.

(4) Ground reading liquid level gage calibrated in 1/8-inch graduations.

(5) Gage hitch with stilling well to within 3 inches of the bottom of the tank.

(6) Inlet fill pipe terminating within 6 inches of the bottom of the tank and equipped with a means so that the operator can limit the flow velocity to 3 feet per second until the inlet is fully submerged.

(7) Provide internal heating coils or suction heaters for tanks intended for viscous product service. Consideration should be given to insulating heated tanks.

(8) Provide open atmospheric vents with weather hoods for tanks to be used for products with true vapor pressure of 1 psia or less. For higher vapor pressure, provide a pressure/vacuum vent. Size vents in accordance with API RP-2000, Guide for Venting Atmospheric and Low-Pressure Storage Tanks. Refer to NAVFAC MO-230, Maintenance Manual Petroleum Fuel Facilities for more detailed discussion on venting.

(9) In addition to normal venting, provide a means for emergency relief venting with capacity in accordance with NFPA 30.

(10) Design the tank installation with the bottom sloped and suction connections, located as described for underground tanks.

(11) At the low end of the tank, provide a 3/4-inch antifreeze type water drawoff valve with internal poppet. The water drawoff valve shall connect to a waste oil tank or an oil/water separator.

(12) For aboveground tanks of 661 gallons or greater capacity, provide a dike or drainage system leading to a dike or similar containment in accordance with Section 5.

Section 3. ABOVEGROUND VERTICAL STORAGE TANKS

1. DESIGN REQUIREMENTS. Vertical aboveground storage tanks shall be cylindrical tanks of welded steel construction with cone roofs. Tanks 40,000 gallons or less in capacity and not over 12 feet in diameter may be shop-built in accordance with UL Standard 142, Standard for Steel Aboveground Tanks for Flammable and Combustible Liquids. Larger tanks should be field erected tanks designed and constructed in accordance with API Standard 650, Welded Steel Tanks for Oil Storage. (See NAVFAC Definitive Drawing 1311350, Typical Tank Farm Layout.)

2. FOUNDATIONS. Tank foundations shall be designed on the basis of a soils exploration program including soil reconnaissance and preliminary exploration as a minimum and detailed exploration and testing when the need is indicated by the results of the minimum program. See Chapters 2 and 3 of NAVFAC DM-7, Soil Mechanics, Foundations and Earth Structures for a detailed description of soils exploration programs and sampling and testing methods to be used.

The results of the exploration program should be analyzed to determine the most practical and economical design to provide a stable foundation for the tank. Designs to be considered should include at least the following:

For all tanks provide good drainage under the tank.

As a minimum for all tanks 10,000 barrels or smaller, provide a stone or gravel foundation pad elevated approximately 18 inches above the finished tank field grade and arranged to provide good drainage under the tank.

As a minimum for tanks larger than 10,000 barrels, provide a reinforced concrete ringwall as shown in Figure 4 and constructed to provide good drainage as described above.

For relatively shallow layers of weak or otherwise objectionable soil, in addition to the foregoing, remove and replace the objectionable material with clean well-compacted granular fill.

For moderately deep layers of material, in addition to the first three requirements, compact the soft material by preloading, dewatering, sand drains, chemical or grout injection or similar techniques.

For deep layers of soft material, consider the use of pile foundations in accordance with Chapter 13 of NAVFAC DM-7.

Differential settlement of storage tanks shall not exceed the values given in Table 6-1 of NAVFAC DM-7. The magnitude of uniform settlement, differential settlement and seismic disturbances should be estimated as part of the design, and adequate flexibility to accommodate any combination of these conditions should be provided in connected piping and other systems.

3. CORROSION PROTECTION. In the tank foundation design, consider the effect of the design and materials of construction on exterior corrosion of the tank bottom. Prevent external corrosion of tank bottoms by setting the tanks well above the general tank field grade, provide adequate tank field drainage away from the tank, and construct the foundation pad of clean, free-draining granular material such as sand, gravel, or crushed stone. Foundation material should have a neutral or alkaline pH; avoid using dredge material. If for some reason these precautions cannot be effectively achieved, use cathodic protection to prevent external corrosion of the tank bottoms as described in Chapter 6.

4. ROOFS. Tanks for storage of products having a true vapor pressure less than 1.5 psi shall have a cone roof in accordance with API Standard 650. These products include kerosene type jet fuels such as JP-5, diesel fuel, kerosene and burner fuel oils.

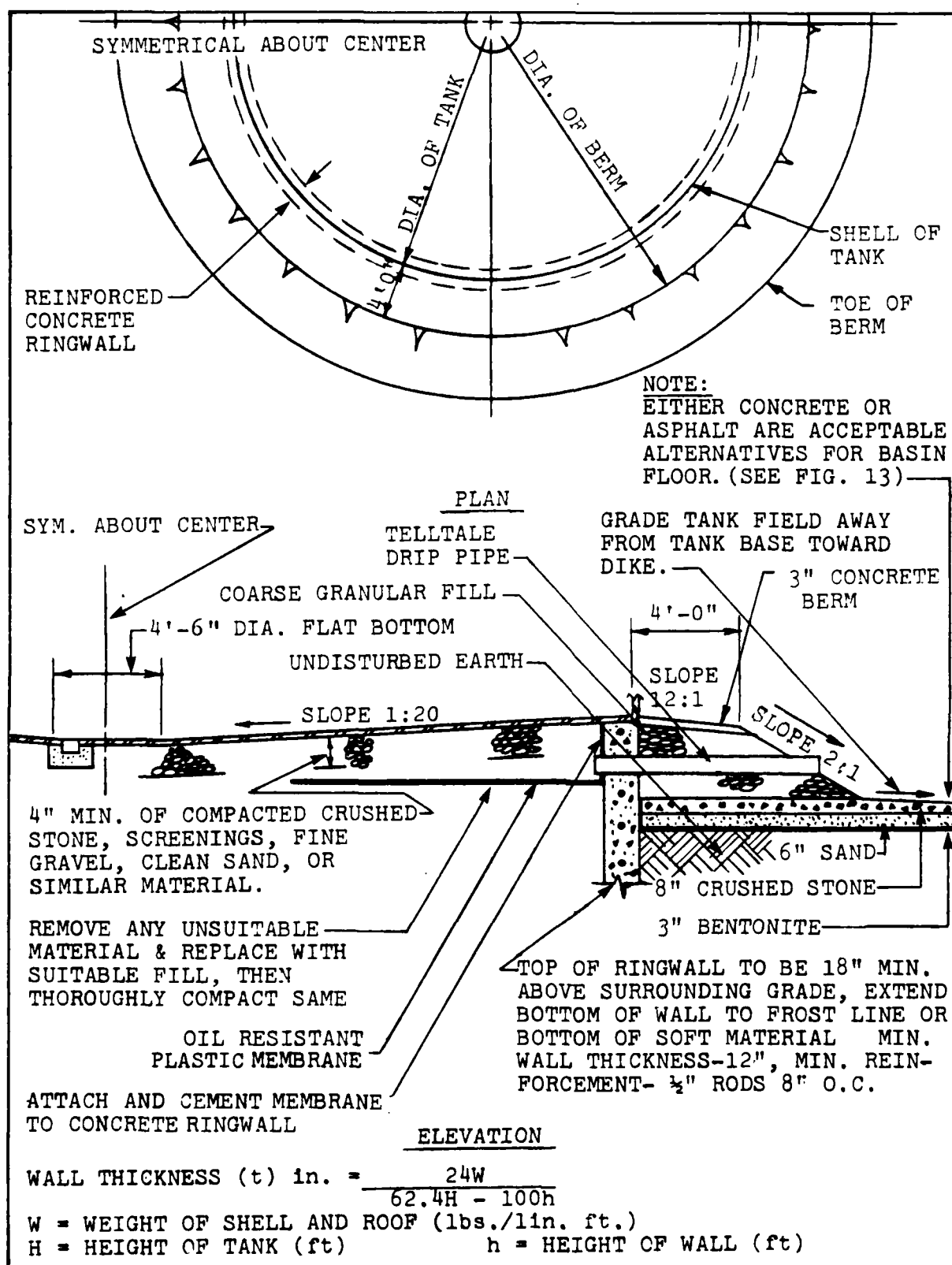


FIGURE 4
Ringwall Foundation for Vertical Tanks

Tanks for storage of products having a true vapor pressure of 1.5 psi or more, such as gasoline at any temperature or JP-4 when the fuel temperature is above 70° F, shall have a cone roof with internal floating pan in accordance with Appendix H of API Standard 650. They shall conform with Departments of the Army and Air Force Bulk Storage Drawings, No. 78-24-27, sheet 1 through 17, and specifications 78-24-27-70-CE, Standard Aircraft Bulk Fuel Storage Aboveground Steel Tanks with Floating Pan and Cone Roof. These standard drawings include tank sizes of 2,500 BBL through 100,000 BBL capacity. This design provides truss supported cone roof to eliminate columns. Other specific features shall be as follows:

Provide a seal between the internal floating pan and the tank shell consisting of a primary seal of flexible petroleum resistant synthetic fabric filled with polyurethane foam and a secondary wiper seal above to prevent escape of vapors which pass the primary seal. Seal effectiveness shall meet prevailing environmental protection standards at the site. Provide comparable seals around all stationary devices which penetrate the internal floating pan.

Provide pressure and vacuum vents in the internal floating pan.

a. Grounding Bonds. Provide grounding bonds between the floating pan and shell as follows:

(1) Three lengths of bare 3/16-inch diameter stranded, extra flexible stainless steel wire rope shall be provided, each extending from the top of the floating pan to the underside of the fixed roof.

(2) Two of the wires shall be attached near the tank periphery 180° apart. The third wire shall be attached to the floating pan manhole cover.

(3) The wires shall be securely welded or brazed to the pan, and the upper ends of the wires should connect at a single point adjacent to a roof inspection opening.

(4) The wires shall have enough length to accommodate the full travel of the pan, and shall be located to miss all interior tank appurtenances and structure.

Equip all exterior vents and ports with weather hoods and bird screens.

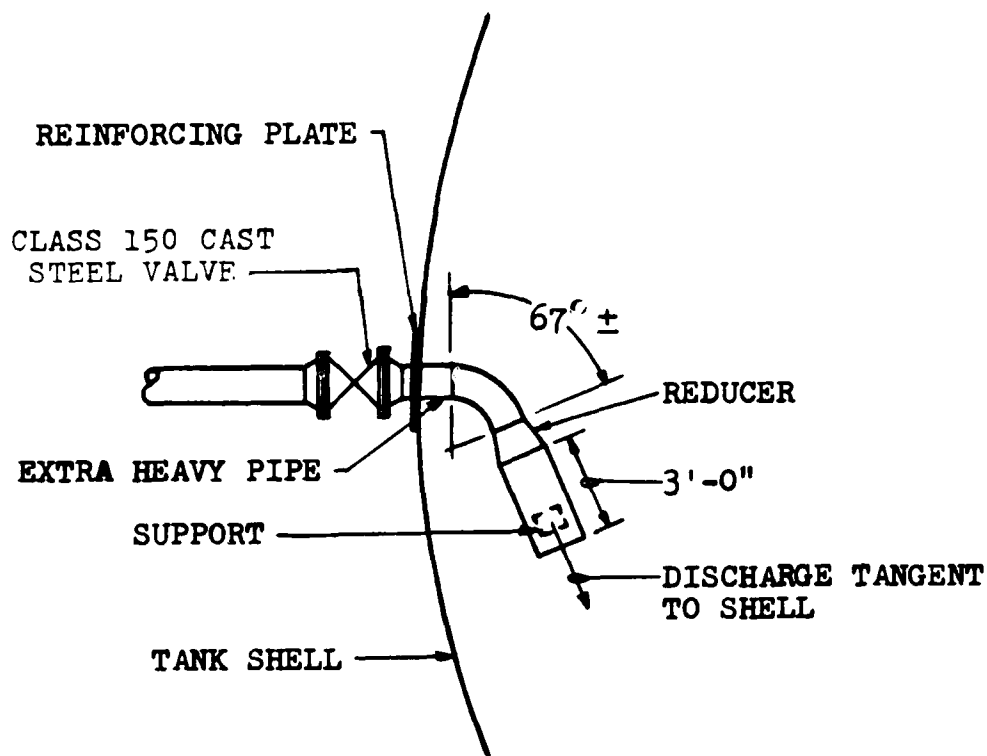
Provide a minimum of two 24-inch inspection hatches in the fixed roof.

Provide thermometer wells in accordance with paragraph 7(f) following.

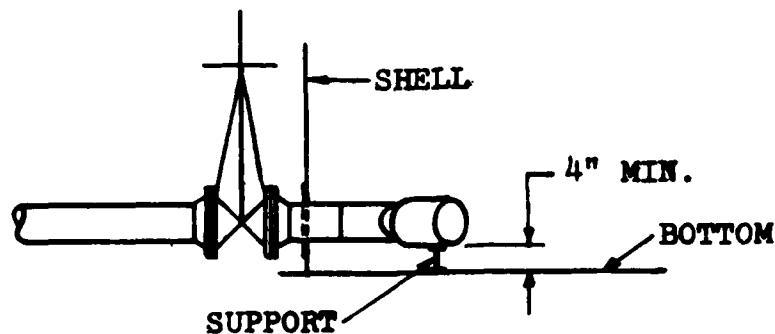
5. **BOTTOMS**. Bottoms of aboveground vertical storage tanks shall slope downward from the shell toward a sump at the center. A slope of 1 foot vertical for 20 feet horizontal is required for positive drainage and self cleaning action. Bottom plates may be butt welded or lap welded with the outer plates on top.

6. **PIPING**.

a. Filling Lines. Figure 5 shows a typical filling connection for an aboveground vertical storage tank. Size the pipe so that the velocity does not exceed 12 feet per second at maximum flow rate. Provide a means so that the operator can reduce the velocity of flow to 3 feet per second until the filling inlet nozzle is completely submerged.



PLAN



NOTE: MAXIMUM INLET VELOCITY SHALL NOT EXCEED 3 FEET PER SECOND UNTIL FILLING CONNECTION IS FULLY SUBMERGED.

ELEVATION

FIGURE 5
Typical Inlet Connection for Vertical Aboveground Storage Tank

b. Outlet Lines. Provide a 6-inch low suction (2-inch at aviation activities) from a point 4 inches above the bottom of the sump to a gate valve on the outside of the shell which shall be connected to the main tank suction line with a tee and blind flange, as shown in Figures 6 and 8. For circulating tanks locate the main suction 6 inches above the top of the sump. Provide an antivortex plate on the sump end of the line. (See Figures 6 and 7.) For noncirculating tanks, locate the main suction 12 inches above the tank floor and 24 inches inside the tank shell. (See Fig. 8.)

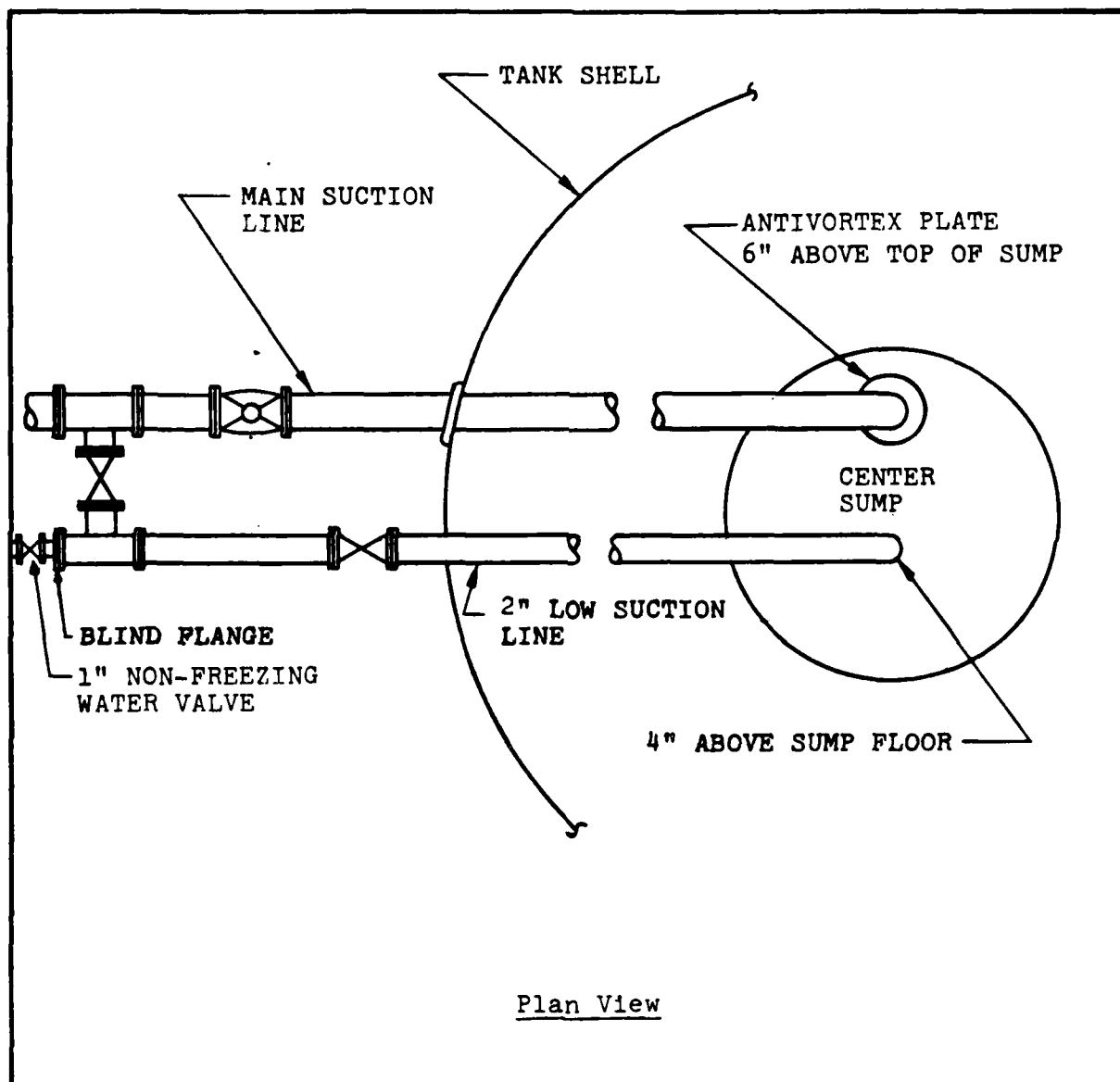


FIGURE 6
Transfer Pump Suction Piping for Vertical
Aboveground Circulating Storage Tank
at Aviation Activities
Plan View

NOTE:

FOR AVIATION FUEL TANKS AT AVIATION ACTIVITIES, LOCATE SUCTION INLET DIRECTLY ABOVE SUMP. FOR OTHER PRODUCTS IT MAY BE LOCATED AWAY FROM THE SUMP. SEE FIGURE 8

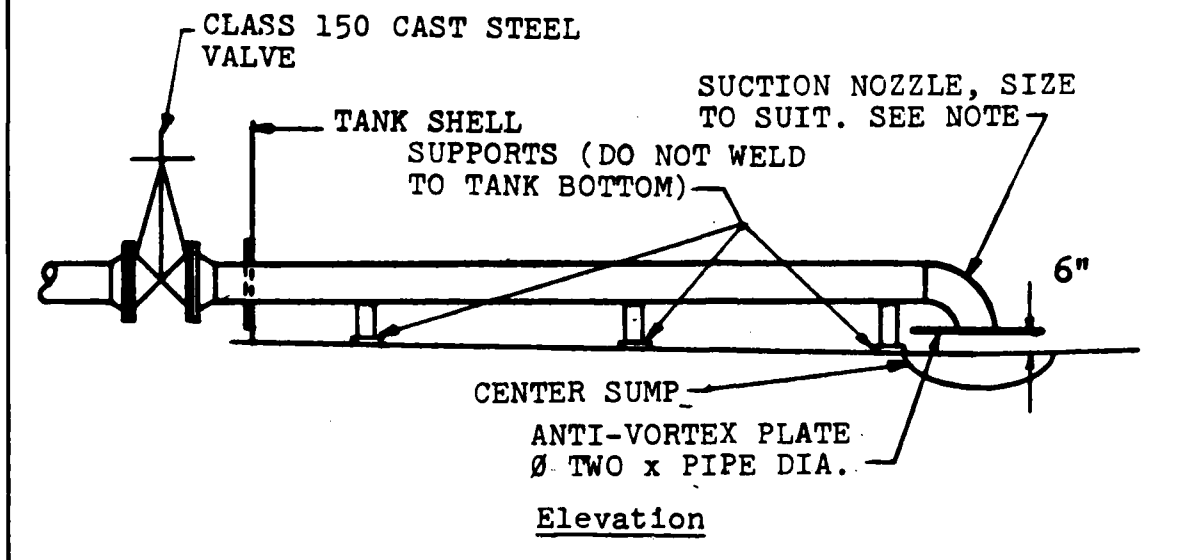


FIGURE 7
Transfer Pump Suction Piping for
Vertical Aboveground Circulating Storage Tank
Elevation

c. Water Drawoff Connection. For noncirculating tanks provide a 1-inch water drawoff connection from a point 2 inches above the bottom of the center sump and extend through the tank shell to a filter/separator, waste tank or oil/water separator.

7. FITTINGS AND APPURTENANCES.

a. Roof Manholes. Design and fabricate roof manholes in accordance with API Standard 650.

Provide a minimum of two 24-inch square inspection hatches on fixed roof tanks. Locate the roof manholes near the perimeter of the roof at opposite ends of a diameter and approximately 90° from the shell manholes.

b. Shell Manholes. Design and fabricate shell manholes in accordance with API Standard 650. Provide two 30-inch shell manholes in each tank at opposite ends of a diameter approximately 90° from manholes.

For covered floating roof tanks, provide one additional shell manhole immediately above the level of the floating pan when the pan is in its lowest position.

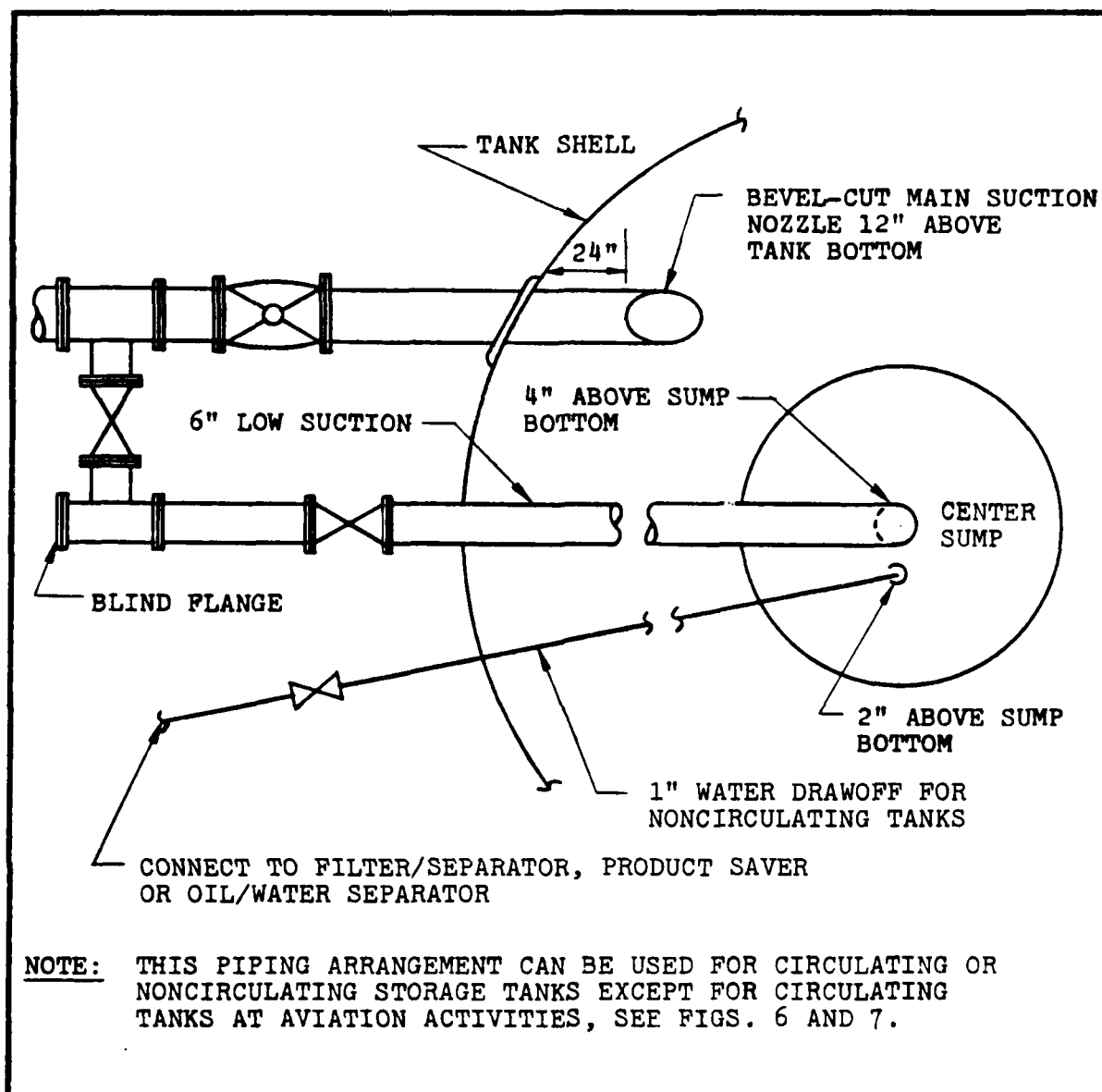


FIGURE 8
Transfer Pump Suction Piping for
Vertical Aboveground Storage Tank

c. **Drain Sumps.** Construct tanks with bottom coned down to the center of the tank. Provide a center drain sump as shown in Figure 9.

d. **Gaskets.** Specify composition asbestos gaskets for all flanged or bolted connections.

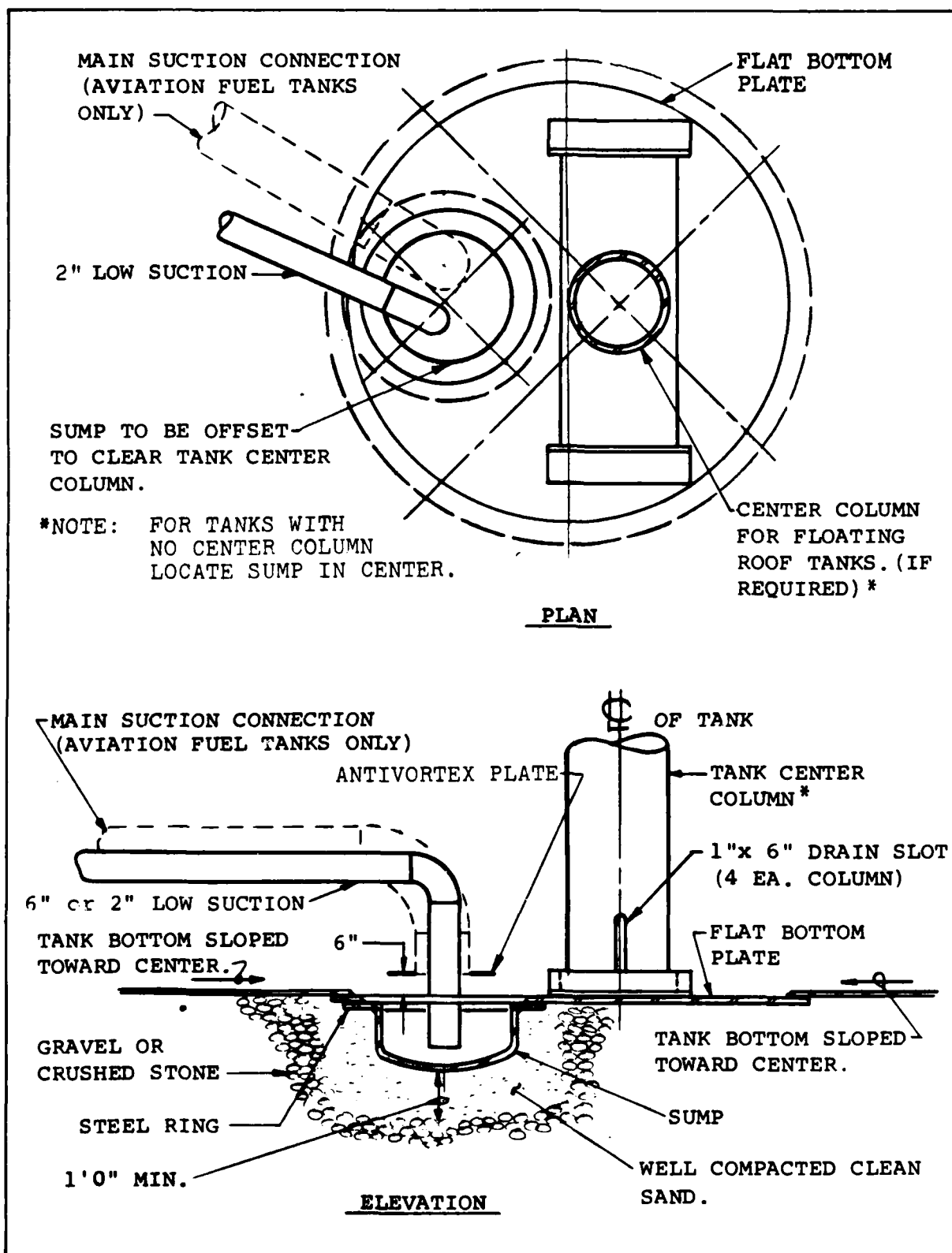


FIGURE 9
Center Drain Sump for Vertical Aboveground Circulating Storage Tank

e. Valves. All tank valves shall have cast steel bodies except the outlet valves from operating tanks serving aviation fuel dispensing systems. All the valves in noncorrosive aviation fuel systems shall be aluminum or stainless steel. Liquid control valves on the shell may be nonlubricated double seated plug or ball valves with body bleed. Lubricated plug valves and butterfly valves shall not be used. Water drawoff valves shall be the double poppet antifreezing type.

f. Thermometers. Provide two thermometer wells designed in accordance with Figure 10 not more than 18 inches apart in each tank. In floating pan tanks, be sure that the wells are below the lowest point of travel of the pan and clear of the pan support legs. In one well, provide a 5-inch mercury-filled direct-drive Bourdon tube dial thermometer with 1-degree divisions and a range of 0° F to plus 150° F or minus 10° C to plus 80° C for unheated tanks. For heated tanks, use 2-degree divisions with a range of 0° F to plus 240° F or minus 10° C to plus 120° C.

The second well is to accommodate temperature-sensing bulbs for remote reading temperature systems or temperature control devices which are to be provided only when specifically authorized.

g. Platforms, Stairways, and Ladders. Provide platforms, stairways, ladders, handrails, railings, and toeboards in accordance with API Standard 650 and the Occupational Safety and Health Act (OSHA).

On the shell of each tank, provide a spiral stairway and top platform in accordance with API Standard 650 and OSHA. Provide railings and toeboards around all platforms.

On the roof of each tank, provide handrailings around the roof perimeter, in accordance with OSHA requirements.

h. Gages and Gage Hatches.

(1) For cone roof tanks, provide a gage hatch and stilling well to within 3 inches of the bottom of the tank. Hatch to be located near the edge of the roof and readily accessible from the top platform of the stairway.

(2) For cone roof tanks with floating pans, provide gage and sampling hatches as described for cone roofs except that each hatch shall have a gage well which penetrates the floating roof through sealed openings and so arranged that gaging and sampling can be accomplished from the top of the tank.

(3) For all tanks, provide an automatic float gage with a ground level readout preferably located near the bottom of the spiral stairway. The float gage should be of the type that can readily be adapted to a remote transmission system. Remote reading temperature devices may also be specified for tanks with remote gaging systems.

i. High Level Alarm. Provide an automatic high level alarm which is completely independent of the gaging device or system for all tanks. The system shall be capable of detecting and transmitting at least two alarm conditions, one at approximately 95 percent of tank capacity and one at approximately 98 percent of capacity. The nature and location of the alarm signal or action shall be as individually specified for each installation.

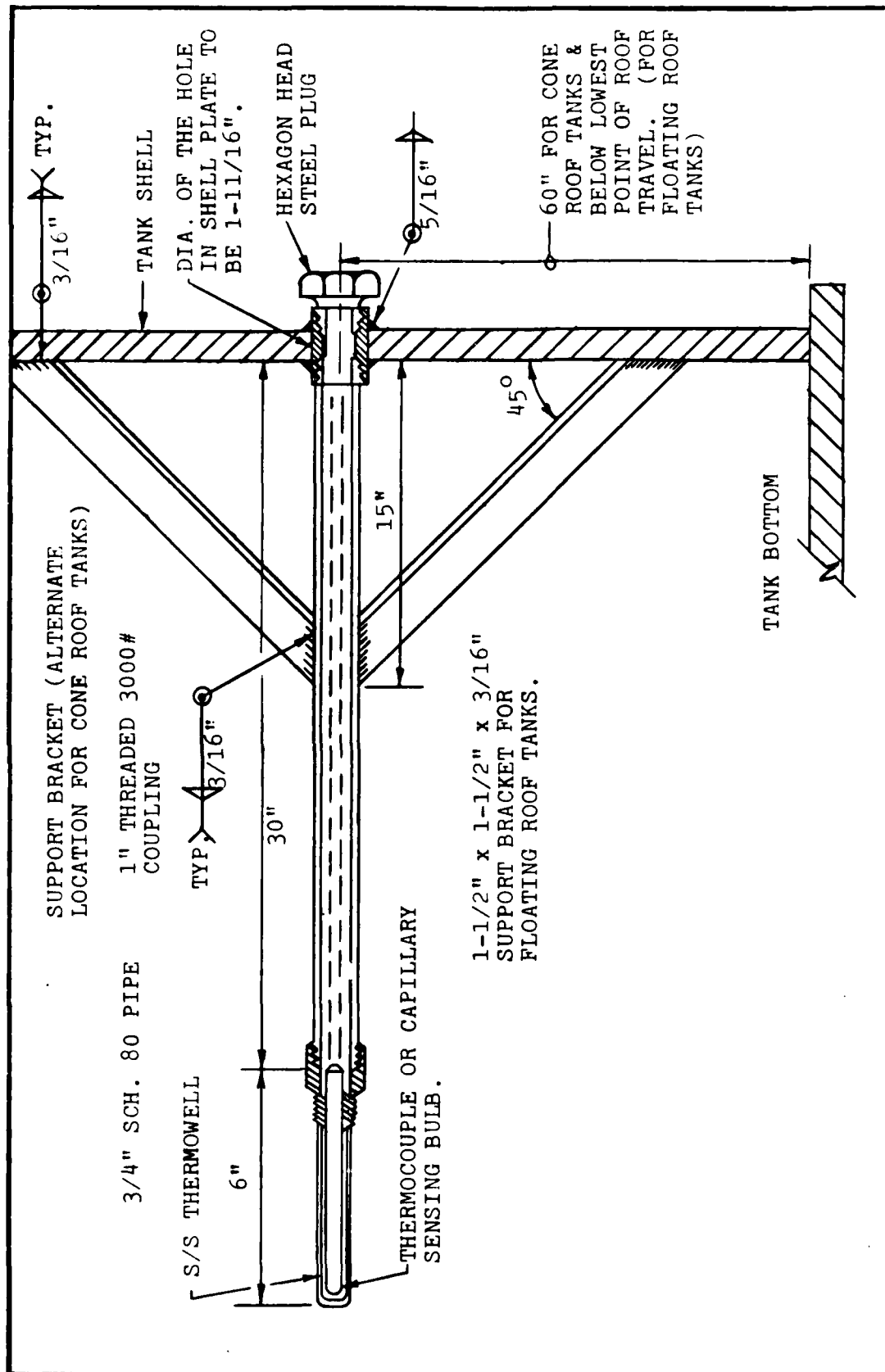


FIGURE 10
Typical Storage Tank Thermometer Well

j. Vents.

(1) For fixed roof tanks, vents shall be sized and designed in accordance with API Standard 650 and API Standard 2000, Venting Atmospheric and Low-Pressure Storage Tanks. Open vents will normally be used for the non-volatile products which are stored in fixed roof tanks. Where especially dirty environments exist, pressure/vacuum vents may be used for kerosene type jet fuel tanks.

(2) For tanks which are not constructed with weakened roof-to-shell seams as specified in Section 3.5.2 of API Standard 650, provide emergency relief vents with capacity for pressure relief during fire exposures in accordance with NFPA Standard 30, Flammable and Combustible Liquids Code.

(3) For cone roof tanks with floating pans, provide ventilators in the fixed roof and vents in the floating pan as described in the preceding paragraph 4.

(4) All external open vents shall be equipped with weather hoods, bird screens and a flame snuffer operable by a pull chain. Flame arrestors shall not be used.

k. Fire Protection. Provide fire protection fittings and connections to meet the requirements of Chapter 7.

l. Tank Heaters and Insulation.

(1) For tanks intended for storage of viscous products such as Burner Fuel No. 6 and, in cold climates, Burner Fuel No. 5, provide tank heaters in accordance with Chapter 1, Section 4 and controls in accordance with Chapter 1, Section 5.

(2) For all heated tanks, the design shall include an economic analysis of the incentives to insulate the tank using the methods described in NAVFAC P-442, Economic Analysis Handbook.

m. Scaffold Cable Support. On the fixed roof of all tanks, including covered floaters, provide a scaffold cable support in accordance with Figure 19 of API Standard 650. Locate the support near the center of the tank and in a manner that supported cables will have maximum range and flexibility of operation with minimum interference with other tank fittings.

n. Corrosion Protection. Provide protection against exterior corrosion of tank bottoms as described in Section 3 of this Chapter.

Provide internal coatings as required in Section 1 of this Chapter.

Section 4. UNDERGROUND VERTICAL STEEL STORAGE TANKS

1. DESIGN REQUIREMENTS. The design of underground vertical steel storage tanks shall be in accordance with NAVFAC DM-2, Structural Engineering. Tank sizes usually should not exceed 100,000 barrels capacity. Tank design shall be in accordance with Department of the Air Force Standards for Underground

Steel Tanks, Drawing AW-78-24-31, sheets 1 through 6 and specifications 78-24-31-72-AF, except as modified herein. These standards include tank sizes of 10,000 through 100,000 barrels capacity. Provide interior coatings for fuel storage tanks in accordance with Section 1 of the Chapter.

2. **BOTTOMS.** Tanks shall have coned-down bottoms which slope downward from the shell at a uniform 1:20 slope to a sump at the center.

3. **PUMPS AND PIPING.** Provide suction, drain, and water drawoff connections from underground tanks as follows:

For water drawoff and tank bottom stripping for circulating tanks, provide a 10 gal/min. vertical turbine pump with the bottom of the suction bell approximately 2 inches from the bottom of the sump connected to a 100 gal/min. filter/separator and a return line to the inlet line of the tank.

For circulating tanks, provide vertical turbine transfer pumps of appropriate capacity, with the bottom of the suction bell 6 inches above the tank floor and as close to the pump as possible. Provide an antivortex plate at the end of the suction bell. (See Fig. 11).

For noncirculating tanks, provide a vertical turbine transfer pump(s) of appropriate capacity with the bottom of the suction bell 12 inches above the tank floor and a 50 gal/min. vertical turbine pump for water drawoff and bottom stripping. (See Fig. 12.)

Where circumstances, such as hillside installation, would permit gravity flow from the underground tank to the point of discharge, provide a gravity discharge connection.

4. **FITTINGS AND APPURTENANCES.**

a. Valves. Provide tank valves as described in Section 3, paragraph 7 of this Chapter. For valves not otherwise accessible from the surface, provide extension stems and handles. Avoid locating valves inside tanks.

b. Thermometers. Provide two thermometer wells in the access pit for gaging and venting. Wells shall be generally as shown in Figure 11 except that they shall be vertical and extend from the slab above the roof to a point approximately 12 inches above the tank bottom. Support each well from a column in at least four places. Thermometers and remote temperature sensing devices, when specified, shall be in accordance with Section 3, paragraph 7 of this Chapter.

c. Stairways and Ladders. In the manhole in the pump pit, provide a fixed ladder to the bottom of the tank. Additional ladders to the bottom may be provided by welding step irons to columns which are accessible from the manholes. All ladders and stairways shall be in accordance with the Occupational Safety and Health Act.

Provide a ladder or stairway for access from the surface to the floor of the pump pit.

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PETROLEUM FUEL FACILITIES DESIGN MANUAL 22(U) NAVAL
FACILITIES ENGINEERING COMMAND ALEXANDRIA VA AUG 82
NAVFAC-DM-22

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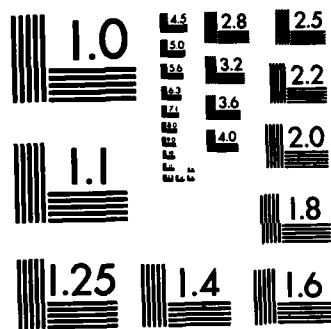
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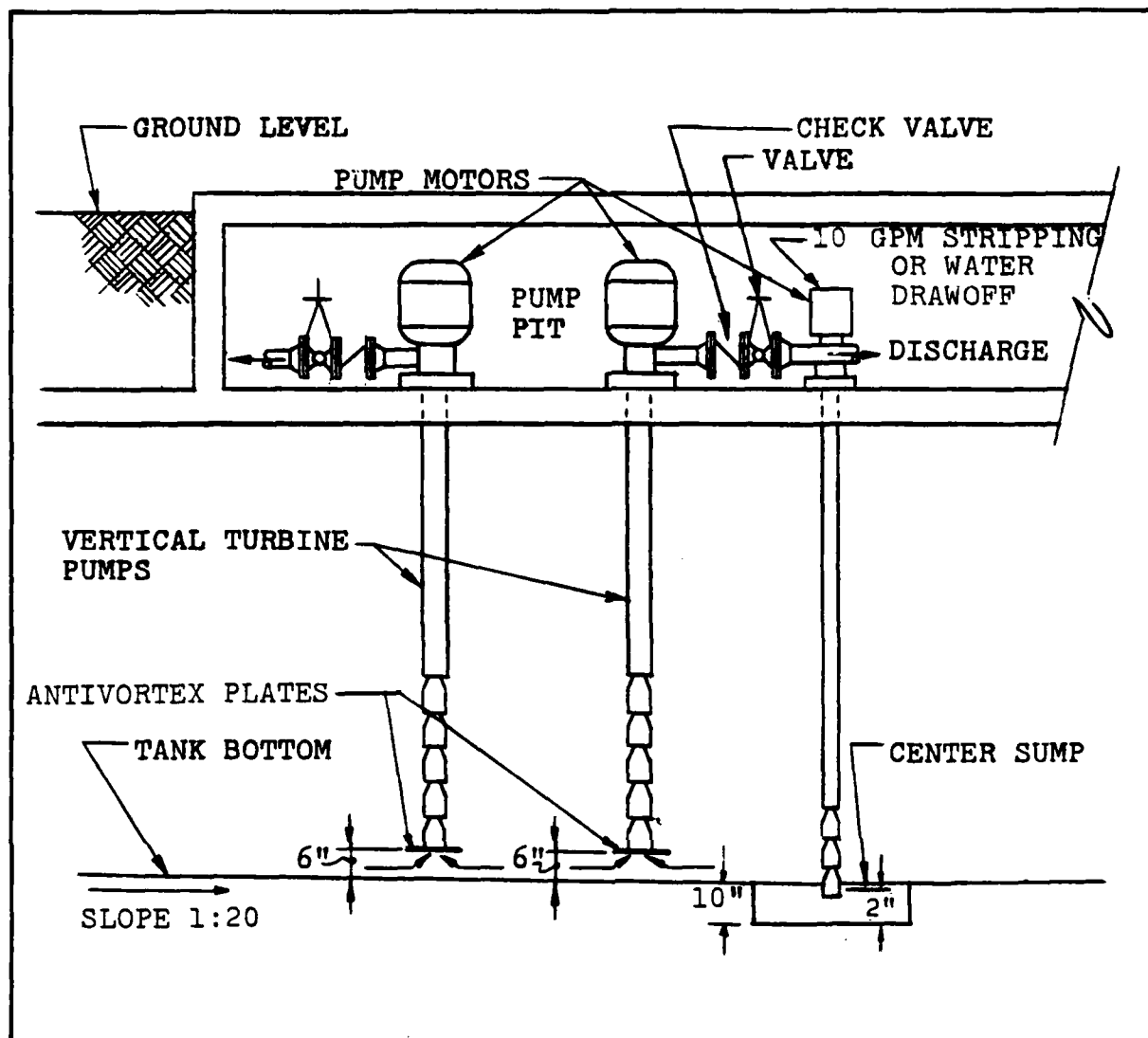


FIGURE 11
Transfer Pump Arrangement for
Vertical Underground Circulating Storage Tank
Elevation

d. High Level Alarm. Provide a separate high level alarm system as described in Section 3, paragraph 7 of this Chapter.

e. Vents. Vent capacity shall be in accordance with API Standard 2000, Venting Atmospheric and Low-Pressure Storage Tanks, for filling and emptying only. Breathing caused by atmospheric temperature changes and emergency relief venting for fire exposures may be disregarded. Breathing caused by tank heaters shall be included in the vent capacity.

Tanks for nonvolatile product service such as diesel fuel, kerosene type jet fuels, and burner fuel oils may have open vents equipped with weather hoods and bird screens. Vent discharge shall be at least 3 feet above the ground over the tank or above the maximum snow level, whichever is greater.

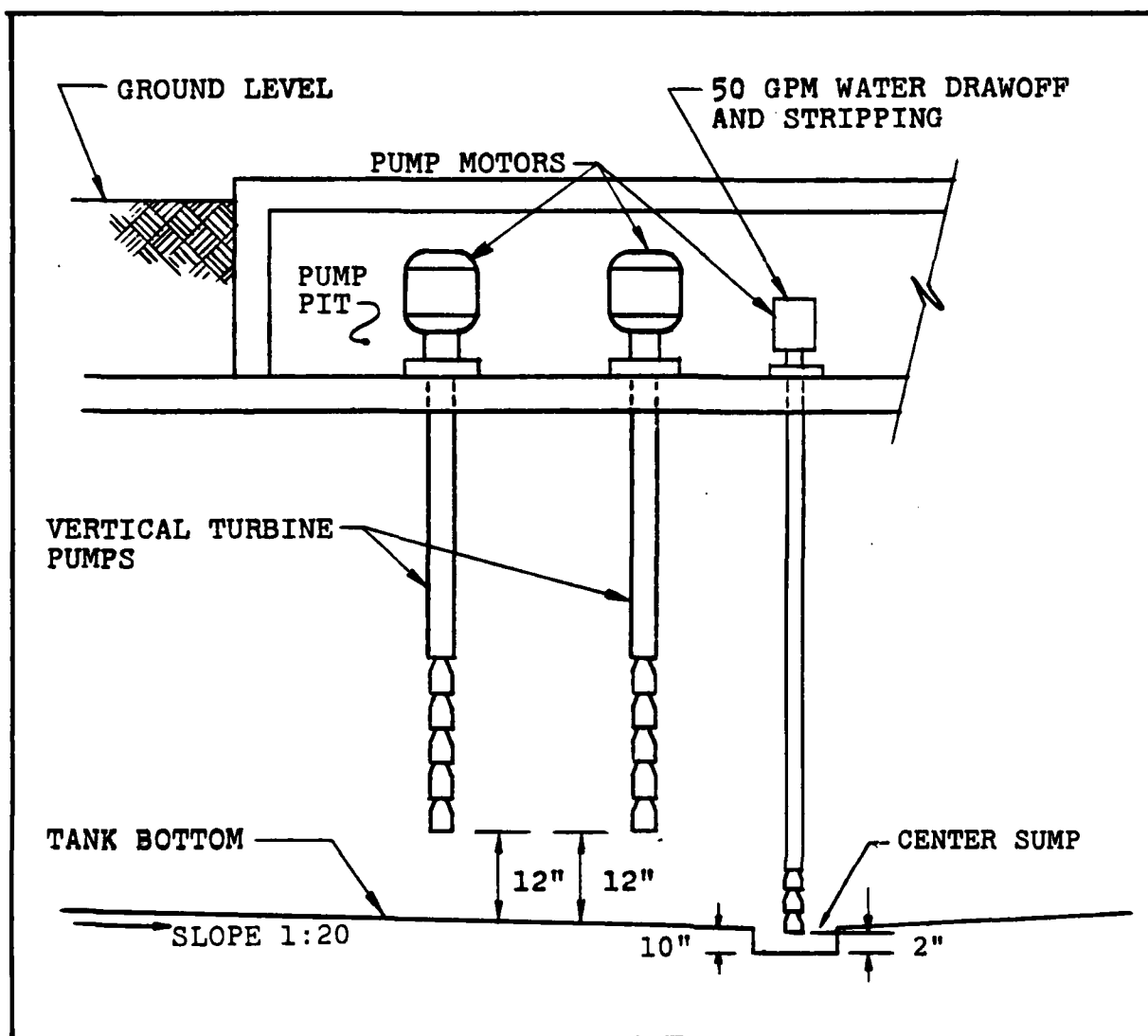


FIGURE 12
Transfer Pump Arrangement for
Vertical Underground Non-Circulating Storage Tank

Tanks for storage of volatile products shall have pressure/vacuum vents or breather valves set to open at a pressure of 1.5 pounds per square inch or a vacuum of 1.5 ounces per square inch. Terminate vents not less than 10 feet outside the tank vent pit or any other tank pit and not less than 12 feet above the ground over the tank or above the maximum snow level, whichever is greater. Provide weather hoods, bird screens, and a flame snuffer operable by a pull chain or other similar means from a point at least 15 feet distant horizontally. Flame arrestors shall not be used.

f. Tank Heaters. For tanks intended for storage of viscous products such as Burner Fuel No. 6, and in extremely cold climates, Burner Fuel No. 5, provide tank heaters or line heaters in accordance with Chapter 1, Section 4 and controls in accordance with Chapter 1, Section 5. Tank heaters should be of a type that can be removed through roof manholes with access manholes provided accordingly.

g. Access Pits. Provide access pits for access through the earth cover to tank fittings and appurtenances including pumps, heaters, valves, gages, gage and sampling hatches, and internal ladders.

The pit shall be constructed of reinforced concrete waterproofed in accordance with Type Specification 07110, Membrane Waterproofing. The access pit shall include weather covers, doors, ladders, and ventilators.

h. Vapor Emission Control System. For tanks intended for storage of products having a true vapor pressure of 1.5 psia or more and located in air pollution control basins in which the discharge of petroleum vapors is controlled or prohibited, provide a vapor emission control system. The vapor emission control system shall have sufficient capacity to control the vapor discharged from the tank vents at maximum filling rate, in such a manner that the discharge conforms to local air quality regulations.

Section 5. TANK ENCLOSURES

1. DESIGN REQUIREMENTS. Provide diked enclosures or spill collection systems leading to impoundments or containments designed to prevent spilled petroleum from leaving the property for all aboveground storage tanks and the aboveground portion of cut and cover tanks larger than 660 gallons capacity. Provide drainage structures designed to impound escaping oil where rupture of an underground tank in a hillside location would endanger other activities and structures at elevations lower than the tanks.

2. DIKED ENCLOSURES. Dikes shall be constructed of earth or of vertical reinforced concrete. Earthen dikes shall be constructed of impervious clay or covered with a layer of such clay, concrete, or asphalt with rubberized coal tar sealer. Tanks larger than 10,000 barrels capacity shall be enclosed by an individual dike for each tank. Groups of tanks 10,000 barrels individual capacity or less and not exceeding 15,000 barrels aggregate capacity may be enclosed in a single dike.

Each diked area containing two or more tanks shall be subdivided preferably by drainage channels or at least by intermediate curbs in order to prevent spills from endangering adjacent tanks within the diked area.

The volumetric capacity of the enclosure for a single tank, as measured from a point 1 foot below the lowest point of the top of the dike, shall be not less than the greatest volume of liquid that can be released from the tank.

The volumetric capacity of the enclosure for more than one tank, as measured from a point 1 foot below the lowest point of the top of the dike, shall be not less than the greatest amount of liquid that can be released from the

largest tank in the group plus the displacement of those portions of other tanks in the group and their foundations which are below the top of the dike.

Dikes shall not exceed an average interior height of 6 feet.

The area within the dike basin shall be sloped in a manner designed to carry drainage away from the tank to a sump located at the low point of the enclosure. Drainage from the sump to the outside of the enclosure shall be controlled by a lock type rising stem gate valve located outside of the enclosure and in a location that will be safely accessible during a fire. The drain valve will be normally closed and will only be opened for draining water from the diked basin. Diked areas are for emergency containment of fuel only. In event of a tank leak or rupture, the drain valve will remain closed, the basin area will be flooded with water and the fuel will be pumped from the top of the water into a tank truck for reclamation or disposal. Under no circumstances will fuel be allowed to run off or escape from the diked area.

a. Earth Dikes. Dikes shall be constructed of earthen materials whenever possible. The minimum distance from the toe of the dike to the tank foundation shall be 5 feet. The top of the dike shall have a flat surface at least 3 feet wide. Slopes shall not be steeper than 1 foot vertical to 1-1/2 feet horizontal. The sides and top of the dike and the basin floor around the tank shall be covered with one of the following materials:

(1) 3 inches of impervious clay such as bentonite covered by 6 inches of sand and 8 inches of crushed stone.

(2) 3 inches of concrete paving or air-blown cement mortar reinforced with woven wire fabric. Expansion and contraction joints shall be provided as necessary. Joint material shall be impervious to the fuel. A typical dike section is shown in Figure 13.

(3) 2 inches of impervious asphalt with rubberized coal tar sealer over 4 inches of compacted base course.

b. Reinforced Concrete Dikes. Where limitations of space or other considerations do not permit the use of earthen dikes, reinforced concrete retaining walls may be used as dikes. Reinforced concrete dikes and their foundations shall be designed to resist and contain the full hydrostatic load when filled to capacity.

c. Area Beneath Tank. The area beneath the tank shall be covered with a fuel resistant plastic membrane with a thickness of not less than 20 mils. All plastic membrane seams shall be carefully fused and/or cemented. The plastic shall be laid over a thoroughly compacted select subgrade free from rocks that could puncture the plastic. Over the plastic provide a minimum 4 inches of compacted clean sand or similar material. The plastic membrane shall be securely attached and cemented to the inside of the concrete foundation ring wall beneath the tank shell (see Fig. 4). A drain pipe or pipes shall be installed through the concrete foundation ring wall so that water beneath the tank can escape by gravity (see Fig. 4). This drain pipe also serves as a telltale for tank bottom leaks.

ALTERNATE METHODS:

1. 3" LAYER OF BENTONITE TYPE CLAY COVERED BY 6" OF SAND AND 8" OF CRUSHED STONE.
2. 2" LAYER OF ASPHALT W/ RUBBERIZED COAL TAR SEALER OVER 4" OF COMPACTED BASE COURSE.

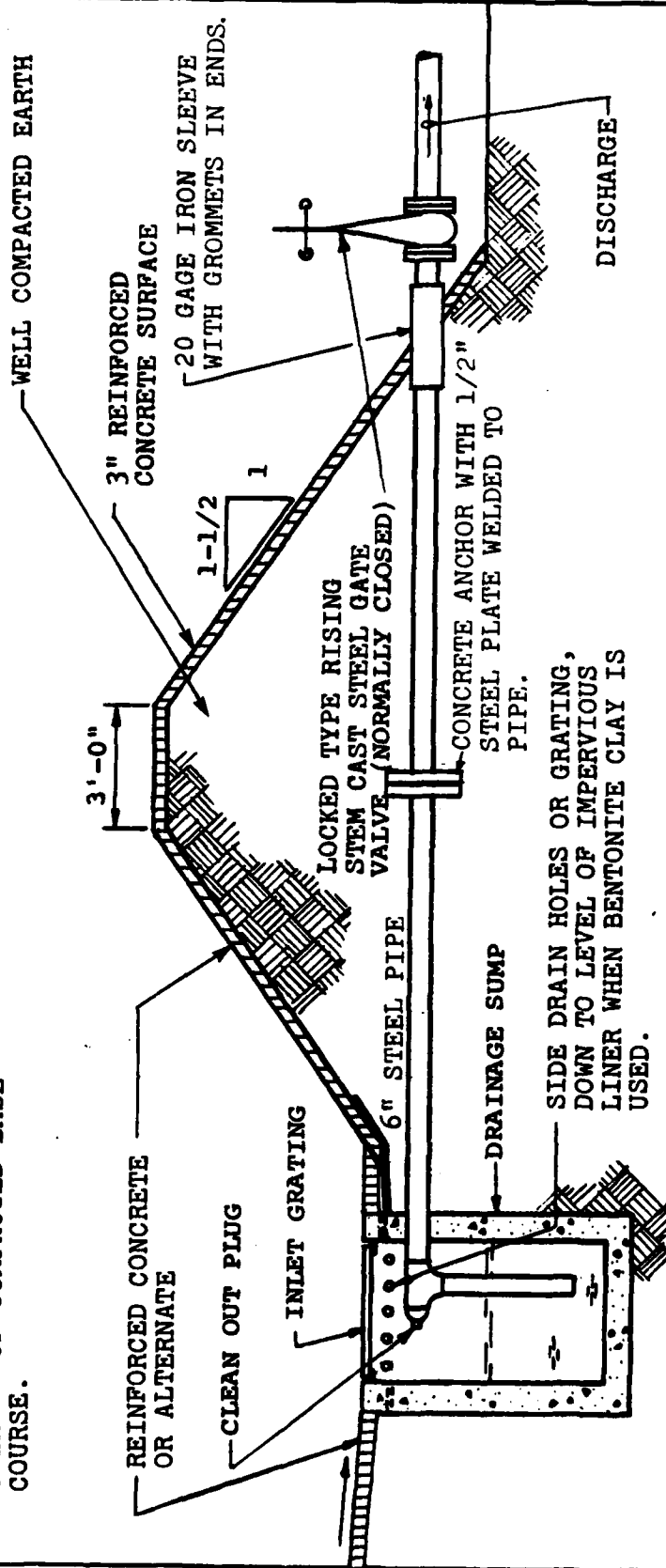


FIGURE 13
Typical Earth Dike with Drain

d. Dike Access. Provide concrete steps with pipe handrails on one side for passage across a dike. Locate steps at the most accessible points, preferably on the same side as the access stairs to a tank roof. For tanks over 50,000 BBL, consideration shall be given to providing earth filled ramps to permit passage of vehicles over the dike. In such cases, a built-up asphalt roadway with rubberized coal tar sealer shall be provided.

3. SPILL COLLECTION SYSTEMS. Spill collection systems consisting of a series of drains leading from storage tank areas to a containment or impoundment designed to prevent the accidental discharge of petroleum from endangering facilities, adjoining property, entering waterways, or otherwise damaging the environment, may be used instead of dike enclosures.

The drainage system can serve more than one storage tank. The drains shall be constructed of petroleum resistant impervious material. The impoundment shall be constructed as generally described for diked enclosures and shall have volumetric capacity, when measured from a point 1 foot below the lowest point of the top of the impoundment, not less than the full content of the largest tank which is tributary to the drainage system. The drainage system and impoundment shall also have capacity to contain the storm runoff from the entire tributary area as determined by NAVFAC DM-5.3, Drainage Systems.

CHAPTER 5. BALLAST TREATMENT AND SLUDGE REMOVAL

Section 1. BALLAST RECEIVING AND TREATMENT FACILITIES

1. **DESIGN REQUIREMENTS.** Ships are not permitted to discharge untreated oily ballast water at sea or into inland waterways as it is the policy of the United States that there shall be no discharge of oil or hazardous substances into or upon the navigable waters of the United States, adjoining shorelines, or into or upon the waters of the contiguous zone. Petroleum fuel facilities, which transfer fuel by barge or tanker, or which fuel large ships may require ballast water collection and treatment facilities to receive and treat oily ballast from cargo or fuel tanks.

Large naval bases may have permanently installed piping and storage systems to receive ballast water from all fueling piers. Where permanently installed ballast collection and treatment facilities are not provided, Ship Waste Offload Barges (SWOBs) and Waste Oil Rafts (DONUTS) can be used to collect and effectively treat ballast water to discharge standards. NAVFAC Manuals MO-909, Oil Ship Waste Offload Barge, and MO-350, Standard Operational Manual for the Waste Oil Raft, fully describe the use and operation of the Oil SWOB and DONUT, respectively, for ballast water collection and treatment. On those vessels with compensating fuel systems (Spruance Class), the ballast water from refueling operations is extremely clean and is free of oil sheen if the prescribed refueling rates are adhered to during refueling operations. However, there are instances where some Spruance class ships have discharge small quantities of oil with the ballast water. In these instances, open bottom DONUTS provide an effective form of ballast water treatment.

The fuel oil which has been reclaimed from the ballast water during the collection and treatment process, should be blended with boiler fuel oil for use in shoreside boilers. However, it is important that quality assurance be performed on the reclaimed fuel oil to insure that it meets the minimum requirements for shoreside boiler fuel. NAVFAC Instruction 10340.7B, Waste Oil Management, of 17 August 1978 provides guidance for the blending of reclaimed oils with burner fuels for use in shore based Navy boilers. Sludge accumulated during the collection and treatment of ballast water should be disposed of in accordance with applicable hazardous waste management disposal procedures.

Selection and design of the appropriate treatment system will require an evaluation of the types of oil/water mixtures that may be encountered at the particular facility.

If possible, the evaluation should be based upon samples of typical ballast water receipts and tank washings including the following information:

- (1) Are they simple mixtures, simple gravity suspensions, or chemically stable emulsions?
- (2) What is the specific gravity and viscosity of the oil in the mixture?

(3) Are there other substances, such as chemicals or bacteria, in the mixtures which must be removed?

(4) What is the general condition of the ship's tanks expected to be discharged: new, clean, coated, well maintained, or, dirty and normally full of sludge, scale, and rust?

(5) Is the ballast water clean sea water, or polluted harbor water?

(6) Can the treatment system proposed (SWOBs, DONUTS or fixed shore based facilities) meet the standards of effluent water quality established by local environmental regulations?

If it is determined that both simple mixtures and emulsions are present, consideration should be given to the possibility of using two segregated separate systems, one for gravity separation and the other for breaking emulsions. Mixing of the two types of suspensions should be avoided when possible. For bilge water and other contaminated oily wastes which require additional treatment, see NAVFAC DM-5.8, Pollution Control Systems.

For typical schematic arrangement of ballast water treatment and disposal systems, see NAVFAC P-272, NAVFAC Definitive Drawing 1311352, Ballast Water Treatment and Disposal Systems.

2. RECEIVING AND SETTLING TANKS. The minimal ballast water receiving facility will usually require two storage tanks, usually of equal capacity, to be used alternately as receiving and settling tanks. If these are sized to allow 4 to 5 days undisturbed settlement, separation of simple suspensions of light oils in water can be achieved. The tanks should be welded steel vertical aboveground storage tanks designed and constructed in accordance with Chapter 4, Section 3 with the following fittings and appurtenances:

(1) Tanks should be internally coated as outlined in Chapter 4, Section 4.

(2) At least two shell manholes and one roof manhole, 30 inches nominal diameter with bolted covers.

(3) One gage hatch for manual gaging, with gaging and thief sampling equipment.

(4) An automatic float gage suitable for use with transmitting device for remote readout.

(5) An audible and visual high-level alarm which is independent of the float gage.

(6) An open vent, equipped with flame snuffer. If the tank is shop built, also provide emergency relief venting.

(7) One cable-operated swing-line assembly on the oil outlet pipe.

(8) One shell fill nozzle.

(9) At least one water drawoff valve, to be nonfreezing type in cold climates.

(10) A fixed ladder for access to the roof, if the tank is under 5,000 barrels capacity; or, a circumferential stairway for larger tanks. Handrails around the periphery of the roof.

(11) Valved sample connections in the shell, having nonfreezing type valves in cold climates, every 2 feet vertically, easily accessible from the ladder or stairway.

(12) When chemical feed is provided, a chemical feed inlet valve, to be nonfreezing type in cold climates.

(13) When air blowing is provided, a perforated pipe air sparger for mixing. The perforations shall be made in the sides of the pipe to avoid plugging by settling solids. Air inlet valve(s) shall be nonfreezing type in cold climates.

(14) Sight glass or look box on oil outlet line.

(15) Sight glass or look box on water outlet line.

(16) Oil sump tank with high level alarm.

(17) Water and oil pumps as required to move fluids from receiving tanks or from oil sump tanks. Pumps for transfer of oily water shall be low speed type to minimize emulsification.

(18) Heaters, if required to reduce oil viscosity and promote separation, shall be either tank wall heaters or internal pipes. If internal pipes are used, they shall be 2 feet above the floor of the tank.

(19) Insulation for tanks which will be regularly operated with heaters on.

(20) Provide automatic temperature controls and thermometers for all heated tanks.

3. OIL/WATER SEPARATORS. It is preferable that the water discharge from storage or settling tanks should pass through an API oil/water separator before being discharged into a water-course or passed on to other treatment processes. The separator should be constructed of reinforced concrete in accordance with NAVFAC DM-2, Structural Engineering. Several separator types are shown on NAVFAC P-272, NAVFAC Drawing 1311357, Oil/Water Separators For Oil Contaminated Water Treatment. The separator should be proportioned in accordance with Chapter 5 of API, Manual on Disposal of Refinery Wastes, also see NAVFAC Specification TS-11301, Packed Gravity Oil/Water Separators.

Section 2. CONTAMINATED FUEL RECOVERY SYSTEMS

1. DESIGN REQUIREMENTS. Contaminated fuel recovery systems are required as means of recovering usable fuel from products that have been contaminated by

other fluids or solids. Each recovery system shall be designed to separate the incoming contaminated fluid into recoverable fuel, water, and sludge. In all cases, provide separate storage tanks and piping systems for high and low flash products. Provide separate tanks that will allow isolation of the fuel, settlement of the fuel, and testing and sampling prior to reissue.

Contaminated fuels may accumulate from the following sources:

- (1) Fuel removed from draining pipelines that cannot be returned to storage without purification.
- (2) Foul or wet fuel oil removed from ships.
- (3) Oil and water mixtures removed from diesel fuel oil, jet engine fuel, and gasoline storage tanks by sump pumps.
- (4) Oil recovered from spills.
- (5) Oil/water separator skimmings.
- (6) Oil separated at a ballast water treatment facility.
- (7) Defueling aircraft (rarely).

2. EQUIPMENT AND APPURTENANCES.

a. Sedimentation Tanks. Provide sedimentation tanks to receive contaminated fuel. These tanks shall be equipped for separate removal of reusable oil, sludge, and water. Tanks shall be welded steel vertical aboveground storage tanks designed and constructed in accordance with Chapter 4, Section 3 and shall have the following fittings and appurtenances:

- (1) At least two shell manholes and one roof manhole, 30 inches nominal diameter with bolted covers.
- (2) One gage hatch for manual gaging, with gaging and thief sampling equipment.
- (3) An automatic float gage suitable for use with transmit device for remote readout.
- (4) Audible and visual level alarms, which are independent of the float gage, one set to operate when tank is two-thirds full and the other when level is 4 feet from top of tank.
- (5) An open vent, equipped with flame snuffer. If the tank is shop-built, also provide emergency relief venting.
- (6) One cable operated swingline assembly on the oil outlet pipe.
- (7) An inlet pipe terminating 3 feet above the tank bottom, fitted with a splash or diffusing baffle.

(8) At least one water drawoff valve, to be nonfreezing type in cold climates.

(9) A fixed ladder for access to the roof, if the tank is under 5,000 barrels capacity, or a circumferential stairway for larger tanks, with guard rails around the periphery of the roof.

(10) Sample connections in the shell, consisting of nonfreezing type valves in cold climates, every 1 foot vertically, easily accessible from the ladder or stairway.

(11) Chemical feed inlet valve where required, to be nonfreezing type in cold climates.

(12) Perforated pipe air sparger for mixing. The perforations shall be made in the side of the pipe to prevent plugging by settled solids. Air inlet valve(s) shall be nonfreezing type in cold climates.

(13) Sight glass or look box on water outlet line.

(14) Water and oil pumps as required.

(15) Return water inlet and distribution pipe near bottom of tank.

(16) Temperature sensors located at one-fourth, one-half, and five-eighths of the tank height with local readout, and remote readout at facility operations center.

(17) Heaters, where required, to prevent freezing in cold weather. If internal pipes are used, they shall be 2 feet above the bottom of the tank.

(18) If heaters are installed, provide automatic controls to prevent overheating.

(19) If the tank is to be heated on a regular basis, provide insulation.

(20) Sump and sludge pump for removing settled solids.

b. Steaming Tanks. Steaming tanks shall be designed for removal of residual oil and sludge by heating. The fittings and appurtenances on the steaming tanks shall be similar to those indicated for sedimentation tanks with the following exceptions:

(1) A return water inlet will not be required.

(2) Heaters will be required. The total capacity of the heaters shall be sufficient to heat the contents of the tank from 50° F to 212° F in 10 hours.

(3) Insulate the tank and provide automatic controls to prevent overheating.

c. Recovered Oil Tanks. After passing through the steaming tanks, fuel is discharged to recovered oil tanks for the various types of fuel. Avoid mixtures between volatile fuels, distillates, and residual fuels. Discharge lines from recovered oil tanks shall lead to specified delivery points. Provide a scraper type or dual basket strainer in the discharge line.

Tanks shall be welded steel vertical aboveground tanks designed and constructed in accordance with Chapter 4, Section 3. Provide the following equipment and appurtenances:

- (1) A 30-inch shell manhole and a 30-inch roof manhole.
- (2) An inlet line and an outlet line.
- (3) A gage hatch for manual gaging and sampling.
- (4) An open vent with flame snuffer.
- (5) If the tank is a shop built tank, provide emergency relief venting.
- (6) An automatic float gage suitable for use with transmitting device for remote readout.
- (7) A high level alarm which is independent of the float gage.
- (8) At least one water drawoff valve, to be nonfreezing type in cold climates.
- (9) Tank thermometers.
- (10) For heavy residual fuel oil tanks, provide a tank heater, controls, and insulation.

d. Separated Water Treatment. Where possible, treat separated water in the final treatment phase of the ballast water treatment facility. Otherwise, provide separate water treatment facilities, including chemical storage and injection equipment if required.

Section 3. SLUDGE REMOVAL SYSTEMS

1. DESIGN REQUIREMENTS. Sludge removal systems are required for installations where the accumulation of sludge in substantial quantities is likely to occur on a regular basis. Sources of such sludge would be from a ballast water treatment system, a contaminated fuel recovery system, or from frequent cleaning of shore or ships' tanks. Sludge removal systems are not required for routine cleaning of clean product storage tanks which occurs on an irregular basis.

2. SLUDGE DISPOSAL.

a. Sludge Containing Recoverable Oil. Where possible, provide pumps, tanks, and piping to return sludge containing recoverable oil to the

contaminated oil recovery system. Where this is not possible, consider transferring the sludge to a refinery or waste oil treatment facility. For additional details, see NAVFAC DM-5.8, Pollution Control Systems, Chapter 10.

b. Nonrecoverable Sludge. A disposal facility for pumpable sludges that are unreclaimable shall include a tank or tanks with transfer pump(s) and piping for receiving sludge and the mixing of other low viscosity waste oils for thinning as required. Such tanks shall be dike enclosed and shall have cone bottoms. Tank heating shall be supplied where climate conditions prove necessary. Transfer pump(s) shall feed sludge into tank trucks or into railroad cars for transfer to a waste oil disposal contractor. Alternatively, a pollution free incinerator or incinerators shall be installed. Transfer pump(s) shall feed sludge to incinerator(s). The incinerator(s) shall have sufficient capacity to handle the volume expected without violating any of the applicable local, State, or Federal air pollution regulations. Any resulting ash or frit should be inert or susceptible to simple chemical treatment to neutralize it or otherwise render it harmless for use as landfill material. The installation shall include any facilities required to remove and collect the ash or frit and to treat it if necessary. Suitable facilities shall be provided to supply fuel and power for capacity operation of the incinerator(s). Enclose the waste disposal area with a security fence to prevent unauthorized entry. Treat the ground in such areas to inhibit vegetation growth with ecologically safe chemicals. This facility shall not be used for the disposal of sand, gravel, rust scale, or other solid nonpumpable matter found on tank bottoms.

For further discussion of disposal methods, see Section 3.11 and 3.22 of NAVFAC MO-230, Maintenance Manual, Petroleum Fuel Facilities.

CHAPTER 6. CORROSION PROTECTION

Section 1. DESIGN REQUIREMENTS

1. **GENERAL REQUIREMENTS.** Corrosion protection for all pipelines, machinery, structures, tanks, and similar equipment shall be provided. Corrosion protection may consist of coating, wrapping, or painting. All underground or underwater pipelines or tanks shall be painted, coated or wrapped, and shall also have cathodic protection.

2. **PAINTING AND MARKING.** Protect all aboveground steel tanks, piping systems, and connected equipment against atmospheric corrosion by application of paint films in accordance with Chapter 4, Section 1.

All pipelines and tanks shall be identified as to product service by color coding, banding, and product names in accordance with Military Standard (MIL-STD) 161D, Identification Methods for Bulk Petroleum Systems. All valves, pumps, meters, and other items of equipment shall have easily discernable painted numbers or numbered corrosion-resistant metal or plastic tags attached with a suitable fastener. Numbers shall correspond to those on the schematic flow diagrams and other drawings for the installation.

Provide precautionary labels for petroleum containers in accordance with the American Petroleum Institute (API) Bulletin 2511, Precautionary Labels.

3. **EXTERIOR COATING AND WRAPPING.**

a. Underground. Protect the exterior surfaces of all underground steel piping systems and the exterior shell of underground horizontal steel tanks by coating or wrapping as follows:

(1) Pipes.

(a) Continuously extruded polyethylene coating system in accordance with NAVFAC TS-09809, Protection of Buried Steel Piping and Steel Bulkhead Tie Rods. This system is preferred for new pipelines.

(b) An acceptable alternative is coal tar double wrapped felt system in accordance with NAVFAC TS-15057, Coal Tar Coating Systems for Steel Surfaces.

(c) For field joints and irregular shaped fittings, use pressure sensitive organic plastic tape spirally wrapped, and lapped in accordance with NAVFAC TS-09809.

(2) Tanks.

(a) Epoxy coal tar, Steel Tank Institute STI-P3 System.

(b) Coal tar primer and enamel in accordance with NAVFAC TS-15057.

(c) Factory applied polyester coating, reinforced with chopped fiberglass. Coating shall have a nominal thickness of 1/8 inch.

Where risers from underground piping extend aboveground, the coating and wrapping shall extend well above the highest expected storm water level but not less than 6 inches. Provide similar coatings or wrapping for the upper portion or steel pilings used to support piping or petroleum piers or wharves.

b. Aboveground. Protect the exterior surfaces of all aboveground steel piping systems and the exterior shell of all aboveground steel tanks by coating as follows:

(1) Pipes and Tanks. Zinc rich primer, one bond or tie coat, followed by two or more coats of vinyl paint in accordance with NAVFAC TS-09873, Exterior Coating System for Welded Steel Storage Tanks Used in Petroleum Service.

(2) Under Pier Piping. For recoating of existing under pier piping, use grease impregnated wrapping tape with 50 percent overlap.

4. CATHODIC PROTECTION. For all underground steel structures which are wrapped or coated, provide cathodic protection in accordance with Chapter 5, Section 3 of NAVFAC DM-4, Electrical Engineering. Also provide cathodic protection for bare steel structures, such as underground tank bottoms, which are exposed to corrosive environments but which are not accessible for coating before and after construction.

For additional information on cathodic protection and coatings, see NAVFAC MO-230, Maintenance Manual, Petroleum Fuel Facilities, and NACE, Control of Pipeline Corrosion.

5. INTERIOR COATINGS. Protect the interior of all steel fuel tanks by interior coatings as described in Chapter 4, Section 1. Similarly protect the interior of steel tanks such as ballast water receiving and settling tanks which will normally contain salt water mixtures.

CHAPTER 7. FIRE PROTECTION

Section 1. DESIGN REQUIREMENTS

1. **GENERAL REQUIREMENTS.** The design of all petroleum fuel storage, handling, transportation, and distribution facilities shall give full consideration to the hazardous nature of the fuels to be handled and their vapors. Fire prevention and protection shall be accomplished by application of the following safeguards:

- (1) Isolation.
- (2) Confinement.
- (3) Elimination of sources of ignition.
- (4) Prevention of uncontrolled buildup of heat or pressure.
- (5) Extinguishment systems and equipment.

Fire protection design shall be in accordance with NAVFAC DM-8, Fire Protection Engineering.

2. PROTECTION OF STORAGE TANKS.

a. **Fire Protection Water.** Provide fire protection water mains, hydrants, valves, pumps, and application devices to permit control of brush and grass fires and cooling of storage tanks in the event of a fire exposure. Provide a minimum of two hydrants. Locate hydrants and valves outside of diked areas. Locate hydrants so that protected exposures can be reached through hose runs not exceeding 300 feet and not more than 8 inches nominal size and branches not less than 6 inches. The maximum water supply rate for a storage tank farm need not exceed 2,500 gal/min. It is desirable to have a relatively unlimited supply of fire water, as from a natural waterway or large reservoir.

b. **Foam Systems.** Provide fixed foam systems for all aboveground storage tanks with fixed roofs, including covered floaters, of 100,000 or more gallons capacity. In large open top floaters with pontoon or double deck roofs equipped with foam dams, fixed foam systems may also be installed for protection of seal areas only. Covered floaters with pan type roofs should be treated in the same manner as cone roof tanks on the assumption that the roof will sink in the event of a fire.

The fixed foam system for storage tank protection should be designed in accordance with NFPA 11, Foam Extinguishing Systems and NFPA 11B, Synthetic Foam and Combined Agent Systems. The system shall be a mechanical (air mixture) system using 3 percent or 6 percent aqueous film forming foam (AFFF) as the liquid foam concentrate. In climates where the liquid foam concentrate may be subject to temperatures below 30° F while in transit or in storage, use "cold foam" AFFF concentrate.

c. **Alarm Systems.** Exterior fire reporting stations should be placed in accessible locations spaced so that it is not necessary to travel more than 500 feet to turn in an alarm. Selection of the type of system should be in accordance with NAVFAC DM-8.

3. PROTECTION OF FUEL PIERS. Piers with fixed piping systems used for the transfer of flammable or combustible liquids shall be located, constructed, and protected in accordance with the following sources:

- (1) NAVFAC DM-8, Fire Protection Engineering.
- (2) NAVFAC DM-25, Waterfront Operational Facilities.

All piers should be protected by fire water systems with hydrants located so that vessels alongside can be reached through hose lines not longer than 300 feet in length. Fire protection water systems on piers subject to freezing temperatures shall be normally dry.

Where foam extinguishing systems exist for the protection of other exposures, such as storage tanks, the foam system, if practical, should be extended to hydrants or monitors located within reach of ships alongside the fuel pier.

Provide alarm systems as described in paragraph 2 of this Section.

4. PROTECTION OF TANK TRUCK AND TANK CAR FACILITIES. For facilities (such as loading stands) used for the transfer of flammable or combustible liquids to or from tank truck, refuelers, tank cars, drums or other portable containers, provide portable dry chemical extinguishers of appropriate size, number, and location for the exposure.

Where foam systems exist for the protection of other exposures, (such as storage tanks) consider extending the foam system to hydrants or monitors located within range of the loading or unloading facility. For very large or critical service facilities, consider using an automatic foam sprinkler system to protect structures, systems, and vehicles.

5. PROTECTION OF AIRCRAFT FUELING FACILITIES. At all ramps and aprons used for fueling aircraft, excluding hot fueling stations, provide portable fire extinguishers in accordance with Section 2-15 of NFPA 407, Aircraft Fuel Servicing. For hot fueling stations use a Twin Agent Unit (TAU) at each station.

CHAPTER 8. PROTECTION OF THE ENVIRONMENT

Section 1. DESIGN REQUIREMENTS

1. **GENERAL POLICY.** It is the firm policy of the Navy to design and construct petroleum fuel facilities in a manner that will prevent damage to the environment by accidental discharge of the fuels to be handled, their vapors or residues. Designs should comply with foreign government, national, State, and local environmental protection regulations which may be in effect at any particular facility.

a. **Regulations.** Within the jurisdiction of the United States these regulations, among others, include the following:

- (1) Code of Federal Regulations (CFR).
- (2) Labor Regulations, 29 CFR Part 1910, Occupational Safety and Health Act.
- (3) U.S. Coast Guard Regulations, 33 CFR Part 154, Large Oil Transfer Facilities.
- (4) Environmental Protection Agency Regulations, 40 CFR Part 60, Standards of Performance for New Stationary Sources.
- (5) Environmental Protection Agency Regulations, 40 CFR Part 112, Oil Pollution Prevention, Non-Transport Related Onshore.
- (6) Council on Environmental Quality, 40 CFR Part 1510.38, National Oil and Hazardous Substances Pollution Contingency Plan.
- (7) Federal Safety Regulations, 49 CFR Part 195, Transportation of Liquids by Pipeline.

Additional data on anti-pollution regulations for specific locations may be obtained from NAVFAC's environmental engineers or from the Navy Environmental Support Office.

Section 2. AIR POLLUTION CONTROL

1. **DESIGN REQUIREMENTS.** Regulations pertaining to air pollution control will vary in their requirements from one locality to another and in type and size of the source. All sources that generate hydrocarbon emissions are required to comply with either State or local regulations or 40 CFR, Part 60, the Environmental Protection Agency Regulations, Standard of Performance of New Stationary Sources. The following are protective measures that may be required for new hydrocarbon sources to meet specific State, local or Federal regulations, within the continental United States (CONUS).

a. **Storage Tanks.** Tanks of more than 40,000 gallons capacity used for the storage of petroleum liquids having a vapor pressure of 1.5 psia or greater at operating temperature must be equipped with a control method which will

remove or destroy no less than 95 percent by weight of the volatile organic compound emissions discharged from the tank at the maximum filling rate. Examples of control methods are a floating roof or pan with a double seal, or connection to a closed vapor recovery system.

b. Truck and Rail Loading Facilities. Tank truck and tank car loading facilities which load an annual average of more than 20,000 gallons per day of fuel having a true vapor pressure of 1.5 psia or greater must discharge the vapors resulting from such operations into a closed system leading to a vapor recovery or disposal system which is capable of removing 90 percent of the petroleum vapor before final discharge into the atmosphere.

c. Truck and Railroad Cars. All tank trucks and tank cars used at facilities which load or unload fuel having a true vapor pressure of 1.5 psia or greater must be designed to be maintained vaportight at all times.

d. Service Stations. Environmental control regulations governing motor vehicle service stations which dispense gasoline vary widely in their applicability in different geographical areas. Specific equipment requirements are not clearly defined at this time in many locations. The design of such a facility should include a careful review of existing and proposed local regulations. The following are examples of control systems that could be required:

(1) A closed vapor system that would return vapors to the delivery vehicle when the storage tanks are filled.

(2) A closed vapor system that would capture vapors normally emitted from a vehicle tank when the tank is being filled.

(3) An on-site vapor recovery or disposal system be used in conjunction with the above.

As a minimum, all new motor vehicle service stations should be designed with piping and fittings in place to accommodate the above requirements when they become applicable.

2. PERMIT REQUIREMENTS. If the new source construction is to take place in a locality that has attained the ozone (hydrocarbon) ambient air standard, an Environmental Protection Agency's Prevention of Significant Deterioration permit is not currently required. The Environmental Protection Agency will shortly formulate Prevention of Significant Deterioration regulations and permit requirements covering hydrocarbon emissions in attainment localities.

If construction is to take place in an ozone nonattainment locality, each new source will be required to meet what is called "the most stringent emission limit." These limits can be either a local regulation or an industry wide practice. This most stringent emission limit will vary from locality to locality. A review of local or state requirements will be required before design is undertaken. It is also required to obtain an emission offset in hydrocarbons before any permit to construct can be granted. The emission offset will require a reduction in hydrocarbon emissions from other sources in the locality where the new source construction is to take place. This reduction will need to be greater than the planned emissions from the proposed

new facility. The offset can be obtained by putting new or better controls on or shutting down of an existing Navy source. Currently, if the emissions offset cannot be obtained within a naval facility, approval from COMNAVFACENGCOM HQ and CNO has to be obtained before any contact or negotiation is undertaken with a nonnaval facility.

Section 3. WATER POLLUTION CONTROL

1. **DESIGN REQUIREMENTS.** Protection of the natural waters against pollution by the accidental or intentional discharge of petroleum is achieved by Federal regulations which are fairly uniform in their requirements and geographic application. In general, the regulations require that petroleum fuel facilities be designed and constructed in a manner that will prevent spillage, and should such a spillage occur, will prevent the spill from leaving the property and entering a waterway. The following design features are necessary to meet these objectives at all facilities having 1,320 gallons or more of aboveground storage, any single tank in excess of 660 gallons, or 42,000 gallons or more of underground storage.

2. STORAGE TANKS.

(1) Controlled drainage from storage tank areas with diked enclosures or drainage systems leading to impoundments. (See Chapter 4, Section 5.)

(2) Drainage treatment systems. (See Chapter 5, Section 1.)

(3) Water bottom control. (See Chapter 4, Section 1.)

(4) Corrosion protection for tanks and piping. (See Chapter 6.)

(5) High level alarm.

(6) Adequate tankfield lighting.

(7) Dependable communications systems.

(8) Fenced enclosures to prevent unauthorized entry.

3. TRUCK AND RAIL LOADING AND RECEIVING FACILITIES.

a. Controlled drainage systems leading to retention facilities with enough capacity to contain a spill equal to the volume of the largest tank truck, refueler, or tank car compartment to be loaded or unloaded.

b. Dependable control of flow into or out of vehicles.

c. Adequate lighting in loading and unloading areas.

d. Dependable communications.

4. **MARINE LOADING AND RECEIVING FACILITIES.** All onshore petroleum facilities which make bulk transfer of petroleum to or from ships, barges, or boats in quantities of 10,500 gallons or more are under the jurisdiction of the U.S.

Coast Guard for matters related to spill prevention. The Coast Guard's regulations include requirements for design features such as hose assemblies, loading arms, closure devices, small discharge containments, discharge removal, testing, communications, and lighting. For additional details, see Chapter 2, Section 1 and Chapter 3, Section 1.

The design of marine loading and receiving facilities should also be in accordance with NAVFAC P-272, NAVFAC Drawing 1403995 to 1403999, Non-Polluting Fuel Piers.

5. **INTERTERMINAL PIPELINES.** The U.S. Department of Transportation regulates the design, construction and operation of interterminal pipelines for liquid petroleum. Requirements are given in 49 CFR, Part 195. Their regulations may effect both safety and environmental protection and may influence the following design considerations:

- (1) Operating pressures.
- (2) Weld inspections.
- (3) Testing.
- (4) Corrosion protection.
- (5) Controls.

CHAPTER 9. LIQUIFIED PETROLEUM GASES

Section 1. INTRODUCTION

1. **SCOPE.** This chapter covers liquified petroleum gas (LPG) installations at naval shore activities and may include receiving, storage, distribution, and vaporizing facilities associated with railroad, truck, or marine loading or unloading racks, or docks depending upon the operational requirements of the activity.

2. **COMPOSITION AND USES.** Composition and Navy uses of liquified petroleum gases are as follows:

a. **Composition.** LPG is furnished under MIL-P-12660, Liquified Petroleum Gas, and is composed predominantly of propane and propylene, with minor amounts of butane isobutane, and butylenes.

b. **Navy Uses.** This paragraph covers the uses for which that LPG fuel is procured and methods of transportation of the fuel.

(1) The Navy uses LPG fuel for general heating, metal cutting and brazing, and in laboratories. LPG is procured in cylinders, or for bulk storage, by tank car or tank truck. Normal cylinders contain 100 pounds of gas, in a liquid state.

(2) Where economically justified, the Navy uses LPG facilities to supplement utility supplied gas systems for meeting peak loads and as a standby where interruption to a supply is possible.

(a) Standby LPG facilities serving large capacity equipment, such as boilers of 200,000 British thermal units per hour and above, may consist of a separate gas system to an alternate set of burners on the equipment.

(b) For a gas system serving multiple small appliances, provide the standby equipment with means for air mixing to dilute the LPG with the proper amount of air to match combustion characteristics of either natural or manufactured gas serving the system in place of the utility-supplied gas, or in conjunction with it to reduce utility peak loads. For air mixing facilities, see Section 2.

3. **LPG CHARACTERISTICS.** The design of LPG storage and handling facilities is governed by the following LPG characteristics:

a. **General.** LPG is odorless, colorless, and non-toxic. To permit easier leak detection, an artificial odor is introduced when shipped from a refinery. Under standard atmospheric conditions the LPG is in the vapor phase, but it is liquified under moderate pressure for shipping and storage. The maximum vapor pressure of commercial LPG is approximately 200 pounds per square inch gage at 100° F.

b. Fire Hazard. In the vapor phase, LPG is a hazard comparable to flammable natural or manufactured gas. The explosive range is 2 to 9.5 percent by volume of air-gas mixture.

(1) Ventilation requires special attention because the gas is heavier than air.

(2) In liquid phase, Liquified Petroleum Gas is a highly volatile flammable liquid. Because of rapid vaporization, an LPG fire is basically a gas fire and a primary rule of fire fighting is to shut off the LPG supply feeding the fire.

(3) Design of LPG installation shall provide emergency shut-off features. (See API Standard 2510, Design and Construction of LP-Gas Installation at Marine and Pipeline Terminals.)

c. Refrigerating Effect. At normal atmospheric pressure, the boiling point of propane is minus 45° F.

(1) When LPG is expanded through a regulator from its vapor pressure to normal service pressures, the cooling effect may freeze the regulator if water is present in the LPG.

(2) Although dehydrated at refinery, precautions must be taken to keep LPG dry. For a water removal method, see Section 2 of this Chapter.

(3) In flashing to vapor from the liquid phase, if abrupt pressure drop occurs, the refrigerating effect can be severe.

Section 2. DESIGN CRITERIA

1. GENERAL REQUIREMENTS. Use the following references for general design and safety standards to be used for all LPG facilities. (Particular sections of standards applicable to types of facilities shall be followed. Where conflicts occur, the more stringent requirements shall be used.)

a. Design Standards. Appropriate standards are as follows:

(1) Regulations for Transportation of Explosives and Other Dangerous Articles. For data on regulations for the transportation of explosives, see Tariff No. 13, Interstate Commerce Commission (ICC) Regulations.

(2) Handbook of Fire Protection. For data, see NFPA 59, Liquified Petroleum Gases at Utility Plants.

(3) Standards for the Storage and Handling of Liquified Petroleum Gases. For those standards regulating storage and handling of LPG, see NFPA 58, Liquified Petroleum Gases, Storage and Handling.

(4) **Liquified Petroleum Gases at Utility Gas Plants.** For regulations and procedures controlling the use of LPG at utility gas plants, see NFPA Standard No. 59, Liquified Petroleum Gases at Utility Plants.

(5) **The Design and Construction of LPG Installations.** For information concerning the design and construction of LPG installations, see API Standard 2510, Design and Construction of LP-Gas Installation at Marine and Pipeline Terminals, Natural Gas Processing Plants, Refineries and Tank Farms, and all standards referenced therein.

(6) **Recommended Practice for the Elimination of Electric Sparks.** For recommended practices for eliminating electric sparks, see Association of American Railroads Circulars No. 17D and 17E, Recommended Practice for the Elimination of Electric Sparks.

(7) **Gases, Fuel, Liquid Petroleum.** For data concerning the handling of gases, fuel, and liquid petroleum, including butane and propane mixtures, see Federal Specification BB-G-110, Butane, Propane and Butane-Propane Mixtures.

(8) **Cylinders, Compressed Gas, Propane, and Butane with Valves.** For information on handling procedures for cylinders, compressed gas, propane and butane valves, see Federal Specification RR-C-910, Cylinders, Compressed Gas, ICC 4BA, ICC 4BW and ICC 4E.

2. **RECEIVING FACILITIES.** Receiving Facilities including transfer methods and transportation rates will be as follows:

a. **General.** LPG may be received by truck, rail, or water for either cylinder (bottled gas) or bulk systems. For correction factors for observed volume and gravity, see ASTM-1P Petroleum Measurement Tables.

b. **Transfer Methods.** Transfer methods shall be as follows:

(1) Small bulk systems designed for truck delivery require no pumping or pressuring facilities. Pumping equipment provided on trucks may be used in lieu of stationary pumps.

(2) LPG vapor piping, employing pumps and compressors, shall be used for unloading tank cars or water borne LPG tanks.

(a) The compressor shall take suction from the vapor space of the storage tanks to be filled through an equalizing line and shall pressurize the tank to be unloaded forcing the LPG out through the liquid unloading line into the storage tank.

(b) When all liquid has been evacuated, the compressor suction shall be reversible so that the LPG gas in the delivery tank can be pumped into the storage tank through a subsurface dip tube.

(c) See Figures 14 and 15 for typical installation. Provide liquid pumps as standbys for compressors.

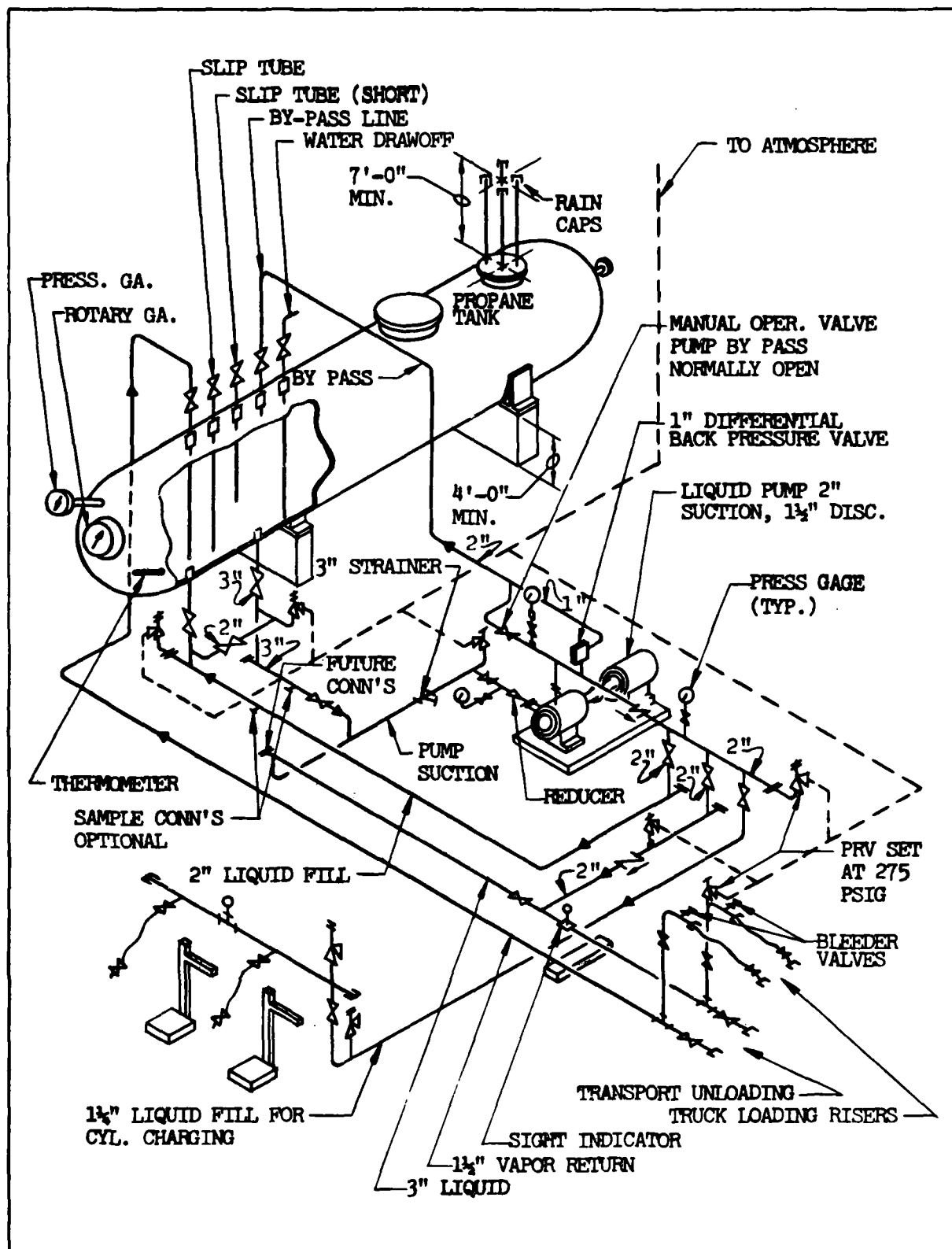


FIGURE 14
Typical Small Volume LPG Facility for Trucks and Cylinders

c. Flow Rates. Rates will be as follows:

- (1) The size of pumps, compressors, and loading devices shall be such as to provide transfer rates commensurate with the storage capacity.
- (2) Flow rates should allow operators adequate time to shut down facilities before tanks or trucks are filled beyond maximum allowable. Flow rates from tanks will be limited by setting excess flow valves.
- (3) Provide unloading lines with manually operated throttle valves so operators can adjust flow rates to points below shut off settings of excess flow valves.

3. STORAGE FACILITIES. Storage facilities will be as follows:

a. Types of Storage. Types of storage will be in cylinders or in bulk storage tanks.

(1) Cylinders or ICC Containers. Provide these as described in NAVSEA 0901-LP-230-0002, Industrial Gases, Chapter 9230. The number of cylinders to be provided at a facility will depend upon the maximum required flow rate and the vaporization rate per cylinder at the minimum operating temperatures.

(2) Bulk Storage. Bulk storage tanks will be as follows:

(a) For storage tanks up to 30,000 gallons capacity, use horizontal steel tanks.

(b) Above 30,000 gallons capacity, use spherical or spheroidal steel tanks.

b. Number and Size of Bulk Tanks. Storage capacity to be provided depends on requirements, frequency of deliveries, and dependability of supply. A multitank system should be considered because it provides more dependability.

c. Underground Tanks. When underground storage is required, or is economically desirable, use horizontal steel tanks.

d. Design Requirements. Design requirements will be as follows:

(1) Tanks, tank appurtenances, and tank spacing shall meet all requirements and recommendations of NFPA Standard 58 and API Standard 2510.

(2) Provide sufficient flexibility in piping connections to tanks to allow for differential settlement of tank and equipment.

(3) Coat underground tanks in accordance with requirements of Chapter 6.

(4) Tanks in use with compressor transfer systems shall be fitted with dip pipes measuring 3/4 inches minimum diameter, and gas inlet lines from compressors, so that gas pumped into storage tanks from empty delivery vessels shall be bubbled through liquid LPG to prevent overpressuring tanks.

(5) Provide float actuated high level alarms set at maximum permissible filling levels on all tanks of 3,000 gallon capacity and above.

(6) Tanks in use with installed transfer systems shall be provided with pressure switches set to open at pressures 5 pounds per square inch below set pressures of safety valves. Such switches shall stop pumps of compressors transferring LPG to tanks.

4. **DISTRIBUTION FACILITIES.** Facilities for distribution shall be as follows:

a. **General Requirements.** Distribution system requirements apply to transfer of both the gas and liquid phases of LPG.

(1) All distribution piping shall be laid underground when practicable.

(2) Flow rates shall be as required. (See Section 2, paragraph 2c. of this Chapter for consideration in determining unloading rates.)

(3) Electrical installations shall be in accordance with requirements of NFPA 70, National Electrical Code (NEC) and API Bulletin RP-500A, Recommended Practice for Classification of Areas for Electrical Installations in Petroleum Refineries. Use only equipment approved for each classified area. The electrical design shall also conform to API Bulletin RP-540 and applicable NEC codes.

(4) Ground and bond all piping, tanks, and equipment in accordance with API Bulletin RP-2003, Standard 2510, RP-540, and applicable NEC codes.

(5) Corrosion protection shall be in accordance with Chapter 6.

b. **Piping.** Pipe, valves, and fittings shall conform to requirements and recommendations of the applicable sections of API Bulletin RP-2510. All materials shall be carbon steel. Requirements of Chapter 1, Section 2 shall apply to the design characteristics and features for gas and liquid pipelines.

c. **Accessories.** Accessory equipment will be as follows:

(1) Meters, pressure gages, thermometers, strainers, and surge suppressors shall meet all design requirements of Chapter 1, Section 2.

(2) Meters, if required, shall be installed in accordance with requirements of API Standard 1101.

(3) Provide pressure gages of suitable range on all tanks, on suction and discharge of pumps and compressors, on inlet and outlet of vaporizers, and on downstream of throttle valves.

(4) Provide thermometers on all tanks, in all transfer lines for both liquid and gas, and on inlet and outlet of vaporizers.

(5) Provide strainers in compressor suctions, upstream of meters, and control valves.

(6) Provide surge suppressors on liquid lines if required.

(7) To remove water from LPG, provide equipment for injecting alcohol into the liquid unloading line during unloading operation at a rate proportional to flow of LPG. Approximate liquid volume ratio of alcohol to LPG for water removal is 1 to 800.

(8) Provide knock-out drums or scrubbers of suitable capacities in suction lines of compressors to remove entrained liquid. Drums shall be provided with high level, shut-down devices, automatic liquid drainers, glass gages, and drains.

d. Pumps and Compressors. Requirements and recommendations of API Standard 2510 and NFPA Standard No. 58 shall apply for pump and compressor design and installation.

e. Vaporizers. All vaporizing equipment for distribution facilities shall be as follows:

(1) Provide vaporizers at locations where liquid temperatures are too low to produce sufficient vapor pressure to meet the maximum required flow rate.

(2) Vaporizers shall be indirect fired type utilizing steam or hot water as heating medium.

(3) Vaporizers shall be sized to provide at least 125 percent of expected peak load.

(4) Vaporizer design and installation shall be in accordance with requirements and recommendations of NFPA Standard No. 58.

f. Controls. Controls will be as follows:

(1) Pumps and/or compressors normally shall be started and stopped by manual pushbutton.

(2) Provide automatic limit switches as follows:

(a) Pressure switches on storage tanks set 5 pounds per square inch below relief valve settings.

(b) Liquid level switches on storage tanks set at maximum filling levels.

(c) Liquid level switches on knock-out drums set to shut off compressor at high liquid levels.

(d) High pressure switches in compressor discharges to shut off compressors at safe pressure levels.

(3) Provide manually operated throttle valves in liquid unloading lines to adjust flow rates below excess flow valve settings on delivery tanks.

(4) Provide sight flow indicator in liquid lines near throttle valves.

(5) Provide automatic temperature, pressure and limit controls on vaporizers as required and recommended by NFPA Standard No. 58.

5. AIR MIXING FACILITIES.

a. Pressure Control. Provide pressure control valves in both air and gas lines to air mixing equipment. Provide a low pressure alarm in each line which will sound an alarm and shut off both air and gas in the event of low pressure in either line.

b. Volumetric Control. Volumetric controls at all distribution facilities will be as follows:

(1) Provide displacement type or flow type meters in both air and gas lines to provide the required proportional flow of air and gas.

(2) A Venturi-type proportioner may be used where the variation in demand flow rate does not exceed the limited range of the Venturi proportioner. Where the demand flow rate varies excessively, the Venturi-type proportioner may be used in conjunction with a downstream storage tank if economically justified. The storage tank will permit a varying rate of flow to the system while being filled continually or intermittently at a constant rate of flow through the proportioner.

c. Specific Gravity Indication. Provide a specific gravity indicator and recorder with high and low limit switches to sound an alarm if the variation of specific gravity of an air-gas mixture exceeds acceptable limits for the system. For air mixing systems using LPG with propane content of 90 percent and above, the specific gravity of the air-gas mixture is a sufficiently accurate index of its British thermal unit (BTU) content, so calorimetric controls and indication are not required.

d. Calorimetric Controls. Where economically justified, an automatic calorimeter may be provided to indicate and record the BTU content of the air-gas mixture. The calorimeter shall have high and low limit switches to sound an alarm if the variation of BTU content exceeds acceptable limits for the system.

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ANSI B31.3, Petroleum Refinery Piping.

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API RP 540, Recommended Practice for Electrical Installations in Petroleum Processing Plants.

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API Standard 650, Welded Steel Tanks for Oil Storage.

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API RP 1004, Bottom Loading and Vapor Recovery for MC-306, Tank Motor Vehicles.

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API Bulletin 1615, Installation of Underground Petroleum Storage Systems at Service Stations.

API Standard 2000, Guide for Venting Atmospheric and Low-Pressure Storage Tanks.

API RP 2003, Protection Against Ignitions Arising Out of Static, Lightning and Stray Currents.

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33 CFR, Part 154, U.S. Coast Guard Regulations, Large Oil Transfer Facilities.

40 CFR, Part 60, Environmental Protection Agency Regulations, Standards of Performance for New Stationary Sources.

40 CFR, Part 112, Environmental Protection Agency Regulations, Oil Pollution Prevention, Non-Transport Related Onshore.

40 CFR, Part 1510.38, National Oil and Hazardous Substances Pollution Contingency Plan.

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TS-02202, Earthwork for Utilities.

NFGS-09872, Interior Coating Systems Used on Welded-Steel Tanks (for Petroleum Fuel Storage).

TS-09871, Lining System, Interior, for Concrete Storage Tanks for Petroleum Fuel.

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P-272, Dwg. 1403995 through 1403999, Non-Polluting Fuel Piers.

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P-437, Dwg. 6028008, Pipeline F/6 Inch Amphibious Assault Submarine Fuel Line.

P-437, Dwg. 6028064, Pipeline, Welded, Sealading, 8-inch, Basic Depth 60 Feet.

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P-272, Dwg. 1293330, Wharf and Offshore Fuel Terminal Configuration.

P-272, Dwg. 1293316, Offshore Tanker Facilities.

P-272, Dwg. 1311350, Typical Tank Farm Layout.

P-272, Dwg. 1311352, Ballast Water Treatment and Disposal Systems.

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P-272, Dwg. 1403985, Aircraft Direct Fueling System, Typical Flow Diagram.

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MIL-F-5572, Gasoline, Aviation.
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MIL-P-12660, Liquified Petroleum Gas.
MIL-V-12003, Valve, Plug, Cast Iron or Steel.
MIL-V-23611, Valve Ball.
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Federal Specifications:

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RR-C-910, Cylinders, Compressed Gas.
VV-G-1690, Gasoline Automotive, Leaded or Unleaded.
VV-K-211, Kerosene.
VV-F-800, Fuel Oil, Diesel, Automotive.
VV-F-815, Fuel Oil, Burner.
WW-V-35, Valve, Ball.

National Bureau of Standards, Handbook 44, Liquid Measuring Devices, Government
Printing Office, Washington, D.C. 20402.

NFPA Standards, National Fire Protection Association, 470 Atlantic Avenue, Boston, Ma. 02201.

NFPA 11, Foam Extinguishing Systems.

NFPA 11B, Synthetic Foam and Combined Agent Systems.

NFPA 20, Centrifugal Fire Pumps.

NFPA 30, Flammable and Combustible Liquids Code.

NFPA 58, Liquefied Petroleum Gases, Storage and Handling.

NFPA 59, Liquefied Petroleum Gases at Utility Plants.

NFPA 70, National Electric Code.

NFPA 77, Static Electricity.

NFPA 78, Lightning Protection Code.

NFPA 87, Piers and Wharves.

NFPA 407, Aircraft Fuel Servicing.

Piping Handbook, Crocker and King, McGraw Hill Book Co., Inc., 1221 Avenue of the Americas, New York, N.Y. 10020.

Regulations for the Transportation of Explosives and Other Dangerous Articles, Tariff 13, Interstate Commerce Commission, Washington, D.C.

Steel Structures Painting Manual, Steel Structures Painting Council, 4400 Fifth Avenue, Pittsburgh, Pa.

UL Standards, Underwriters Laboratories, Inc., Chicago, Il.

UL Standard 58, Standard for Steel Underground Tanks for Flammable and Combustible Liquids.

UL Standard 142, Standard for Steel Aboveground Tanks for Flammable and Combustible Liquids.

GLOSSARY

ACIDS - Chemical compounds containing hydrogen which is capable of being replaced by positive elements to form salts, having pH values less than seven; sour, corrosive.

ADDITIVES - Chemicals that are added in minor proportions to fuels or lubricants to create, enhance or inhibit selected properties; example Fuel System Icing Inhibitor (FSII).

ADHESIVE - Sticky or tenacious; glue.

AFFF - Aqueous film forming foam.

ALKALIS - Chemical compounds containing a reactive oxide which form salts when combined with acids, having pH values greater than seven; caustic, lime, hydroxides.

AMBIENT - Encompassing on all sides, as temperature.

ANAEROBIC BACTERIA - Bacteria having the ability to live without air.

ANODE - The positively charged electrode of an electrolytic cell.

ANSI - Abbreviation for American National Standards Institute.

ANTI-FREEZE - A substance having a low freezing point, usually used to inhibit freezing of cooling system fluids in engines; alcohol, glycol.

ANTI-KNOCK ADDITIVE - An additive used in gasoline to inhibit engine knock (pre-combustion); tetraethyl lead.

API - Abbreviation for American Petroleum Institute.

API GRAVITY - Petroleum industry scale for measuring the density of oils.

ARC - A luminous electrical discharge between two electrodes, as in arc welding or arc lamp.

AROMATIC HYDROCARBONS - Hydrocarbons characterized by the presence of the hexagonal benzene ring; also having an aroma.

ASME - Abbreviation for the American Society of Mechanical Engineers.

ASTM - Abbreviation for the American Society for Testing Materials.

ATMOSPHERIC PRESSURE - The pressure exerted by the earth's atmosphere, when measured at sea level under standard conditions is equal to 14.7 pounds per square inch.

ATMOSPHERIC TANK - Storage tank which operates at or near atmospheric pressure. (14.7 psi at sea level.)

AUTO-IGNITION TEMPERATURE - The temperature at which a substance will ignite without the further addition of energy from an outside source.

AVGAS - Common contraction for aviation gasoline.

BALLAST WATER - Water carried in ship's fuel tanks or cargo tanks to improve the vessel's stability when empty of petroleum.

BARREL - Measure of volume as used in the petroleum industry, equivalent of 42 U.S. gallons.

BERM - An annular shelf or apron, an extension of the foundation of a surface fuel storage tank, to take the spilling of water from the tank roof during rainy weather in order to protect the ground area around the tank from erosion.

BLACK OIL - General term applied to dark-colored residual fuel oils.

BLEND - Combustion or mixture of two or more grades of fuel.

BLIND FLANGE - Piping flange with no passage through the center.

BLOW DOWN - Small valved connection used to purge sediment from the bottom of a strainer body or boiler drum.

BOILER FUEL OIL - Fuel oil that is burned in furnaces to create steam or hot water, also called burner fuel oil.

BOILING POINT - The temperature at which the vapor pressure of a liquid is equal to the pressure of the vapor above the liquid, usually atmospheric pressure. The temperature increases as the atmospheric pressure increases.

BOND - Electrical connection between two objects which equalizes their potential.

BOOM - Flexible floating barrier consisting of linked segments designed to contain free oil on the surface of a body of water.

BOOSTER PUMP - Pump installed along the run of a long pipeline for the purpose of increasing pressure.

BOTTOM LOADING - Method of filling tank trucks or tank cars through a tight connection at the bottom.

BREAKAWAY COUPLING - Coupling designed to part easily with a moderate pull.

BREATHING - The movement of vapors into or out of a container because of natural cyclical heating and cooling.

BS&W - Common abbreviation for bottom sediment and water as found in the bottom of fuel tanks, also; a type of sampling procedure.

BUNKERS - Common expression referring to heavy residual boiler fuel.

CALIBRATION - Adjustment of the scale of a graduated device to meet an established standard, especially applicable to the adjustment of meter registers to indicate true volume as determined by a standard measure.

CATALYST - A substance that provokes or accelerates chemical reactions without itself being altered.

CATHODE - The negatively charged electrode of an electrolytic cell.

CATHODIC PROTECTION - A method for preventing the corrosion of metals by electrolysis.

CELL - A single unit for conversion of chemical to electrical energy by electrolysis.

CENTISTOKE - A unit of measurement of kinematic viscosity, one one-hundredth of a stoke equals one square centimeter per second.

CENTRIFUGAL PUMP - A rotating device which moves liquids and develops liquid pressure by imparting centrifugal force.

CENTRIFUGAL SEPARATOR - A rotating device which separates liquids of different density by centrifugal force, a form of centrifuge.

CETANE NUMBER - A measure of ignitability for diesel fuel.

CFR - Code of Federal Regulations.

CHEMICAL FOAM - Fire extinguishing foam made by mixing two powdered chemicals with water.

CLARIFIER - Commonly used name for a micron filter.

CLEAN PRODUCT - Refined light petroleum products such as gasoline or distillates, as differentiated from residuals or black oils.

CLEAR AND BRIGHT - Description of uncontaminated fuel indicating a complete absence of haze, free water or particulate matter.

CLOUD POINT - The temperature at which a fuel develops a cloudy or hazy appearance due to the precipitation of wax or moisture. The condition developed is called TEMPERATURE HAZE.

CO₂ - Chemical notation for carbon dioxide; fire extinguishing agent.

COALESCER - A filter designed to cause very small drops of water to form larger drops (coalesce) which will separate from fuel by gravity.

COMBUSTIBLE LIQUID - Any liquid having a flash point at or above 100° F. (37.8° C)

COMBUSTIBLE VAPOR INDICATOR - Device which measures the quantity of combustible vapor in the atmosphere; explosion meter.

CONTAMINATED FUEL - Petroleum fuel containing suspended or emulsified water, cleaning chemicals; or other foreign matter such as iron scale, dust, or other solid particles; or containing an unacceptable percentage of noncompatible fuel or other liquids; or containing more than one, or all of these classes of contaminants.

CONTAMINATION - The accidental addition to a petroleum fuel of some foreign material (contaminant) such as dirt, rust, water, or accidental mixing with another grade of petroleum.

COPPER-COPPER SULPHATE ELECTRODE - Reference electrode used to measure structure-to-soil potentials for corrosion control; a half cell.

CORROSION - The process of dissolving, especially of metals due to exposure to electrolytes.

CRUDE OIL - Petroleum in its natural state prior to refining.

DEAD-MAN CONTROL - A control device, such as a switch or valve, designed to interrupt flow if the operator leaves his station.

DENSITY - The mass per unit volume of a substance.

DETERGENTS - Chemical compounds which act as wetting agents, emulsifiers, and dispersants.

DIKE - An embankment or wall, usually of earth or concrete, surrounding a storage tank to impound the contents in case of a spill.

DIP PIPE - Internal vertical pipe running from an inlet nozzle at the top of a storage tank to a point near the bottom of the tank, for submerged filling to prevent splashing and foaming.

DISSOLVED WATER - Water which is in solution with fuel as opposed to free water in suspension.

DISTILLATE - Common term for any of a number of fuels obtained directly from distillation of crude petroleum, usually includes kerosene, JP-5, light diesel, and light burner fuels.

DOWNGRADE - To use a fuel for a lesser purpose than originally specified, often because of contamination.

DROP PIPE - Vertical pipe on the end of a loading arm, which is lowered into the loading hatch of a railroad tank car or tank truck to permit submerged loading.

ECOLOGY - The science of the relationship between organisms and their environments, commonly used to mean the relationship between the works of man and our natural surroundings.

EFFLUENT - Stream flowing; discharge.

ELECTRODE - Electric conductor through which an electric current enters or leaves an electrolyte.

ELECTROLYSIS - Chemical change, especially decomposition, produced in an electrolyte by an electric current.

ELECTROLYTE - A substance capable of forming solutions with other substances which produce ions and thereby permit the flow of electric currents.

ELECTRONIC CONDUCTOR - A substance which permits the flow of electric currents without permanent physical or chemical change; copper, aluminum.

EMULSION - A suspension of small globules of one liquid in a second liquid with which the first will not mix.

ENVIRONMENT - The combination of external social, physical, and natural conditions which surround and influence the existence of man and other organisms.

EPOXY COATING - A coating of thermosetting resins having strong adhesion to the parent structure, toughness, and high corrosion and chemical resistance, also used as an adhesive.

ETHYL GASOLINE - Gasoline containing tetraethyl lead additive.

EVAPORATE - To change into vapor.

EXPLOSIVE LIMITS - (UPPER AND LOWER) - Limits of percentage composition of mixtures of combustible vapors and air which are capable of producing an explosion or combustion when ignited; also flammable limit.

EXPLOSION-PROOF - Classification of electrical enclosures for use in hazardous areas designed to prevent the passage of internal arcs, sparks or flames.

FENDER - Part of a pier structure designed to absorb the impact of a moving vessel.

FIBER GLASS - Composite material consisting of glass fibers in a matrix of resin such as epoxy, used for the structural body for tanks, pipes, boat hulls and as a lining for same, Fiber Reinforced Plastic (FRP).

FILTER - A porous substance through which a liquid is passed to remove unwanted particles of solid matter.

FILTER/SEPARATOR - A filter or combination of filters designed to remove particulate matter and also coalesce entrained water.

FLAMMABLE LIQUID - Any liquid having a flash point below 100° F (37.8° C) and a vapor pressure not exceeding 40 psia at 100° F.

FLASH POINT - The temperature at which a combustible or flammable liquid produces enough vapor to support combustion.

FLOATING ROOF TANK - Petroleum storage tank with a roof that floats on the liquid surface and rises and falls with the liquid level.

FLOCCULATION - A treatment process in which waste waters are clarified by the addition of chemical coagulants to produce finely divided precipitates which will agglomerate into larger particles.

FREE WATER - Undissolved water content in fuel.

FREEZE POINT - The temperature at which wax crystals form in distillate fuels and jet fuels.

FRP - Fiber reinforced plastic.

FSII - Fuel systems icing inhibitor.

FUEL OIL - See Boiler Fuel Oil.

FUEL QUALITY MONITOR - A special type of filter designed to interrupt the flow of fuel when dirt or water content becomes too great.

GALVANIZING - Rust resistant zinc coating applied to iron and steel.

GASOLINE - A blend of light volatile liquid hydrocarbons mainly used as fuel for spark ignition in internal combustion engines.

GROUND - An electrical connection to earth.

GUM - A sticky rubber-like substance formed by the oxidation of petroleum products during use and storage.

HAYPACK FILTER - A filter which uses hay, straw, or excelsior as a filtering medium.

HAZARDOUS AREA - Electrical classification for areas where flammable or combustible liquids or vapors may be present.

HOT REFUELING - Refueling of aircraft which have one or more engines running.

HYDRANT SYSTEM - Distribution and dispensing system for aviation fuels consisting of a series of fixed flush type outlets or hydrants connected by piping.

HYDROCARBON - A compound made up exclusively of hydrogen and carbon in various ratios and molecular arrangements.

HYDROSTATIC HEAD - Pressure caused by a column of liquid.

HYDROSTATIC TEST - A test for leaks in a piping system using liquid under pressure as the test medium.

IGNITION TEMPERATURE - The minimum temperature required to initiate or cause self-sustained combustion independent of any heating or heated element.

IMPRESSED CURRENT SYSTEM - A cathodic protection system using as outside source of electric power.

INERT MATERIAL - Any solid, liquid, or gaseous substance not combustible or fire-producing when exposed to the atmosphere under ordinary climatic conditions; it includes common metals, packing materials, ceramic materials, construction materials such as concrete, mineral aggregates, and masonry.

JP FUEL - Fuel used in turbine type internal combustion engines.

KEROSENE - A general term covering the class of refined petroleum which boils between 370° F and 515° F, mostly used in oil lamps and cooking stoves.

KEROSENE TYPE JET FUEL - JP fuel derived from kerosene without the addition of naphtha; characterized by a flash point of 100° F or more.

KINEMATIC VISCOSITY - The ratio of viscosity of a liquid to its specific gravity at the temperature at which the viscosity is measured.

LEAD HAZARD - Poisonous contamination of the atmosphere, sludge, or other surroundings, particularly in petroleum storage tanks, caused by tetraethyl lead or its residues.

LPG - Abbreviation for liquified petroleum gas; propane, butane.

LUBE OIL - Common contraction for lubrication oil; used to reduce friction and cool machinery.

MAXIMUM - The greatest allowable quantity.

MICRON - A unit of length equal to one millionth of a meter, especially used as a measure of the size of very fine particles found as contaminants in fuel.

MIL - A unit of length equal to one thousandth of an inch, especially used to measure the thickness of paints and coatings.

MILITARY SPECIFICATIONS - Guides for determining the quality requirements for materials and equipment used by the military services (MIL).

MILL SCALE - A magnetic coating formed on the surface of steel during processing in mills.

MINIMUM - The smallest possible amount.

MOGAS - Common contraction of motor gasoline, referring to fuel for land vehicles as differentiated from avgas.

NACE - National Association of Corrosion Engineers.

NAPHTHAS - Refined petroleum which boils at 80° F to 440° F, used as a component of gasoline and solvents.

NAVAIR - Naval Air System Command.

NAVFACENGCOM HQ - Naval Facilities Engineering Command Headquarters.

NAVSUP - Naval Supply Systems Command.

NFPA - Abbreviation for the National Fire Protection Association.

NIPPLE - Short length of pipe, usually used to make side branch connections.

NONDESTRUCTIVE TESTING - A method of inspecting materials to determine their thickness, the location of cracks, flaws, inclusions and other internal discontinuities which can be conducted without cutting, drilling or otherwise destroying the material; usually used to examine steel plates, pipes, and welds. Specifically includes X-rays, gamma ray, ultra-sonic, and magnetic particle inspections.

NOZZLE - A spout or connection, usually with a control valve through which fuel is discharged into a receiving container.

NOXIOUS - Harmful to the body, poisonous.

OCTANE NUMBER - A numerical measure of the antiknock properties of automotive gasoline as measured against standard reference fuels, under controlled laboratory conditions. Iso-octane is a reference fuel whose octane number is given a value of 100.

OFF-SPEC - Commonly used contraction for off-specification, usually referring to fuel which is contaminated or otherwise deficient in quality.

OIL/WATER SEPARATOR - A device used to separate mixtures of oil and water, usually by the difference in specific gravity and usually to protect the environment from contamination by the oil.

OILY-WATER MIXTURES - Mixtures in which water comprises more than half the total. Most such untreated mixtures contain less than 15 percent oil, some of which may be in emulsified form.

OPERATIONAL STORAGE - Storage tanks from which fuel is issued directly to the final-use vehicle such as a ship or aircraft, sometimes called day tanks or ready issue tanks.

ORIFICE PLATE - A plate with a hole in the center held between two flanges in a pipeline, used to create a drop in pressure which is proportional to flow and can be used to measure the flow or to modulate control devices.

PANTOGRAPH - A series of pipes, joined by flexible joints, used to connect fueling equipment to aircraft.

PARAFFIN - White or colorless wax derived from or present in petroleum fuels.

PARALLEL - Very broadly, being similar in nature and direction such as two parallel lines. Two or more pumps having common suction and discharge connections are said to be connected in parallel.

PARTICULATE MATTER - Made up of solid particles, refers to fuel contaminants, such as dirt, grit, and rust.

PETROLEUM - A natural, yellow-to-black flammable liquid mixture of hydrocarbons mostly found beneath the earth's surface.

pH - A number assigned to various substances by chemists to indicate the concentration of hydrogen ions which in turn indicates whether the substance is acidic or alkaline, pH 7 is considered neutral, less than 7 is acidic and more than 7 is alkaline.

PIGGING - The use of cleaning devices, called pigs or go-devils, to clean out the inside of pipelines.

PIG TRAPS - An arrangement of valves and closure devices to trap cleaning pigs at the end of their run through a pipeline.

PILE CLUSTER - A group of pilings driven close together and usually wrapped with wire rope to act as fender or mooring for small vessels.

POL - A commonly used contraction which broadly refers to all petroleum fuels, oils, and lubricants.

POUR POINT - The lowest temperature at which an oil will pour or flow without disturbance.

PONTOON ROOF - A type of floating roof for a storage tank having liquid-tight compartments for positive buoyancy.

PRESSURE DROP - The loss in pressure of a liquid flowing through a piping system caused by friction of pipe and fittings, velocity, and change in elevation.

PSI OR PSIG - Abbreviation for pounds per square inch, the unit of pressure measurement; gage pressure above atmospheric.

PSIA - Pounds per square inch absolute; pressure above an absolute vacuum.

RADIOGRAPH - An image produced on radiosensitive film by invisible radiation such as X-ray, specifically the image produced by radiographic inspection of welds and plates.

RECOVERABLE FUEL - That portion of the fuel oil which may be separated and collected from a given lot of contaminated fuel, by proper processing in the treating facility in question.

RECOVERED OIL - This term sometimes is used to denote untreated petroleum fuel removed from oil-water separators or picked up after being spilled on land or water. It is also used instead of the more correct term "reclaimed oil" to mean oil which has been separated from and collected from a given lot of contaminated fuel by processing in a treating facility. The context usually clarifies the meaning.

REFUELER - Tank vehicles used to resupply aircraft with fuel.

DEFUELER - Tank vehicle used to remove fuel from aircraft.

REID VAPOR PRESSURE - Vapor pressure measured under controlled conditions (psia) with the liquid temperatures at 100° F.

ROTARY PUMP - A positive displacement pump which operates in rotary fashion such as a vane, gear, bucket, lobe, or screw pump; not centrifugal, turbine, or propeller pumps.

RELAXATION TANK - Small tank in a fuel dispensing piping system downstream of filter/separators or fuel quality monitors designed to remove static electricity from the liquid stream before discharge into a receiving tank.

RUST - Ferric oxide, a reddish-brown scaly or powdery deposit found on the surface of steel and iron as a result of oxidation of the iron.

SAE - Abbreviation for Society of Automotive Engineers, used in conjunction with specification for viscosity of lubricating oils.

SCRAPER - A type of cleaning pig used in pipelines.

SEPARATOR - A device capable of separating mixtures of two or more liquids such as oil and water; OIL-WATER SEPARATOR, FILTER SEPARATOR, API SEPARATOR.

SKIMMER - A device used to collect thin layers of oil floating on a body of water.

SLOP OIL - Oil or fuel which has become contaminated with other oils or substances, often requiring separation or treatment before it is fit for use.

SLUDGE - Heavy viscous oily mass found in the bottom of storage tanks and treatment vessels, often contains rust, scale, dirt, lead additives, wax, gum, or asphalt.

SPARGER - Arrangement of perforated pipes in the bottom of a storage tank in distribute air or gas bubbles through the contents, usually to blend or clarify the contents.

SPECIFIC GRAVITY - The ratio of the weight in air of a given volume of a substance to the weight in air of an equal volume of distilled water (62.4 lbs. per cu. ft.), both taken at the same temperature, usually 60° F.

SSPC - Steel Structures Painting Council.

SSU - Commonly used abbreviation for Saybolt Seconds Universal, the time in seconds for 60 cubic centimeters of fluid to flow through a capillary tube in a viscosity measuring device called a Saybolt viscosimeter.

STATIC ELECTRICITY - Accumulation of electric charge on an insulated body; also the electrical discharge resulting from such accumulation.

STRAPPING - The process of determining the volume of a storage tank or cargo hold by measuring its linear dimensions.

STRIPPER PUMP - A pump used to strip or remove the last bit of liquid from a tank or pipe.

SUMP - A low area or depression which receives drainage.

SURGE - Sudden increase in fluid pressure caused by sudden stopping of a moving stream as by a quick closing valve; hydraulic shock.

SWOB - Ships Waste Offloading Barge.

SURGE SUPPRESSOR - Device designed to control or reduce surges; hydraulic shock absorber.

TETRAETHYL LEAD - A lead commonly used as an antiknock additive in gasoline.

THIEF SAMPLE - A sample taken from the bottom of a storage tank, usually to determine the amount and condition of bottom sludge and water.

TOLERANCE - An allowable variation from a specified standard of measurement, commonly applied to the accuracy of meters.

TOP LOADING - Method of filling tank cars and trucks through an opening in the top.

TRUE VAPOR PRESSURE - Vapor pressure measured at actual liquid temperature.

VAPOR LOCK - Malfunction of an engine fuel system or of a pumping system caused by vaporization of the fuel, usually associated with gasoline.

VAPOR PRESSURE - Internal pressure of vapor in a liquid usually in pounds per square inch; an indication of volatility. When vapor pressure exceeds the pressure in the vapor space above the liquid, bubbles of vapor escape and the liquid is said to boil. REID VAPOR PRESSURE is vapor pressure measured at 100° F. TRUE VAPOR PRESSURE is vapor pressure measured at actual liquid temperature.

VISCOSITY - Measure of the internal resistance of a fluid to flow or movement, most commonly measured in Saybolt Seconds Universal; see SSU.

VOLATILITY - Measure of the tendency of a liquid to vaporize; vapor pressure.

WASTE OIL - Oil from which the water and other contaminants cannot be removed by the available treating facilities, and hence is unfit for further use. This term is also loosely used for contaminated oil which may contain recoverable fuel collected at facilities having no treatment facility for fuel reclamation.

WATER BOTTOM - Free water which has settled to the bottom of a storage tank.

WATER DRAWOFF - A valve or similar device used to remove water from the bottom of a tank.

WATER SLUG SHUTOFF - A valve in the discharge piping from a filter/separator which closes automatically when the water in the unit rises above a set level.

WAX - Viscous or solid high molecular weight hydrocarbon substance; paraffin.

WEATHERPROOF - Type of enclosure for electrical apparatus for outdoor service in nonhazardous areas.

WHARF - A landing place where vessels tie up to load or unload; pier.

WHITE GAS - Gasoline which contains no tetraethyl lead.

APPENDIX A

METRIC CONVERSION FACTORS

The following metric equivalents are approximate and were developed in accordance with ASTM E 621. These units are listed in the sequence as they appear in the text.

Conversions are approximate.

288 feet = 89 meters

24 feet = 7.3 meters

1 inch = 25 millimeters

120,000 square feet = 11,160 square meters

Conversions are not given for nominal pipe sizes which are in inches following the general international usage.

Chapter 1.

Section 1.

5.a	59° API	=	0.7 410 kilograms per cubic decimetre (kg/dm ³)
	65° API	=	0.7 182 kg/dm ³
	7 psia	=	48.3 kilo Pascals (kPa)
	9 psia	=	62.1 kPa
	12 psia	=	82.7 kPa
	14 psia	=	96.5 kPa
	(Minus) 45° F	=	(Minus) 43 Degrees Celsius (°C)
	60° F	=	15° C
	1.13 Centistokes	=	1.13 Square millimetres per second (mm ² /s)
	20° F	=	(Minus) 7° C
	25 cu. ft.	=	0.59 Cubic metres (m ³)
5.b.	70° API	=	0.700 4 kg/dm ³
	(Minus) 50° F	=	(Minus) 46° C
	1.00 Centistokes	=	1.00 mm ² /s

5.c. 45° API	= 0.7999 kg/dm ³
2 psia	= 13.8 kPa
3 psia	= 20.7 kPa
(Minus) 20° F	= (Minus) 29° C
140° F	= 60° C
150° F	= 66° C
100° F	= 38° C
60° F	= 15° C
1.81 Centistokes	= 1.81 mm ² /s
3.32 Centistokes	= 3.32 mm ² /s
3.64 Centistokes	= 3.64 mm ² /s
7.36 Centistokes	= 7.36 mm ² /s
(Minus) 72° F	= (Minus) 57° C
(Minus) 51° F	= (Minus) 46° C
(Minus) 46° F	= (Minus) 43° C
(Minus) 58° F	= (Minus) 50° C
5.d. 41° API	= 0.818 4 kg/dm ³
0.5 psia	= 3.4 kPa
110° F	= 43° C
60° F	= 15° C
2.71 Centistokes	= 2.71 mm ² /s
5.e. 35° API	= 0.8 479 kg/dm ³
125° F	= 51° C
140° F	= 60° C
100° F	= 37° C
6.00 Centistokes	= 6.00 mm ² /s
10.32 Centistokes	= 10.32 mm ² /s

10° F = (Minus) 12° C

20° F = (Minus) 6° C

For conversions of Tables 1 and 2 see Pages A-15, and A-16.

6.1 5 feet = 1500 mm

25 feet = 7.6 mm

3 feet = 910 mm

18 inches = 450 mm

10 feet = 3.0 m

n. 75 feet = 22.9 m

Section 2.

1.b. 7 ft/sec = 2.13 metres/second (m/s)

12 ft/sec = 3.66 m/s

120° F = 48° C

130° F = 54° C

1.c. 2 in/100 ft = 14 millimetres per 100 metres
(mm/100m)

35° API = 0.847 9 kg/dm³

50.9° API = 0.774 0 kg/dm³

60° F = 15° C

0.005/°F = 0.000 275/°C @ 15° C

6 inches = 152.4 millimetres (mm)

1 mile = 1.61 kilometres (km)

For conversions of Table 3, see page A-17.

2.b. 1/16 inch = 2 mm

3,000 pound = 1 360 Kilogram (kg)

400° F = 204° C

300 psi = 2.07 Mega Pascals (MPa)

200° F = 93° C

3.b.	0 psi	= 0 MPa
	160 psi	= 1.1 MPa
	4-1/2 inches	= 114 mm
3.d.	7 mesh per inch	= 0.25 mesh per mm
	60 mesh per inch	= 2.4 mesh per mm
	20 mesh per inch	= 0.78 mesh per mm

3.e. In formula 1-1 use metres in lieu of feet. For values of "a" use the following:

	4,455 ft/sec	= 1 358 metres per second (m/s)
	4,410 ft/sec	= 1 344 m/s
	4,370 ft/sec	= 1 322 m/s
	4,250 ft/sec	= 1 295 m/s
	4,230 ft/sec	= 1 289 m/s
	4,132 ft/sec	= 1 259 m/s
	4,060 ft/sec	= 1 237 m/s
	1,000 feet	= 610 m
	2,000 feet	= 1 220 m
	1,600 gal/min	= 100 cubic decimeters per second (dm ³ /s)
	323 psi	= 2.23 MPa
	800 gal/min	= 50 dm ³ /s
	173 psi	= 1.19 MPa
	275 psi	= 1.90 MPa
	100° F	= 38° C
3.f.	120 volts	= 120 volts (v)
	240 volts	= 240 v
	750 watts	= 750 watts (w)
	150 watts	= 150 w
	140° F	= 60° C

4.	18 inches	= 0.46 m
5.	18 inches	= 0.46 m
6.a.	4 feet	= 1.4 m
6.b.	36 inches	= 0.91 m
	6 inches	= 147 mm
7.a.	12 feet	= 3.7 m
	2 feet	= 0.61 m
	50 pounds	= 22.7 kg
	60 pounds	= 27.2 kg
7.b.	200 feet	= 61 m
7.e.	200 feet	= 61 m

Section 3. None

Section 4.

2.	120° F	= 49° C
	130° F	= 54° C
	24 inch	= 0.61 m
	60° F	= 15° C
	175 psi	= 1.2 MPa
	0.2 psi	= 1.4 kPa
	10 psi	= 69 kPa

Section 5.

4.b.	150 horsepower	= 112 kilowatts (kW)
5.a.	1/16 inch	= 1.6 mm
	1° F	= 0.55° C @ 15° C

Section 6. None

Section 7.

1.	300 feet	=	91.4 m
	500 feet	=	152.4 m
	100 feet	=	30.5 m

Chapter 2.

Section 1.

1.a.	15 feet	=	4.6 m
	10 feet	=	0.3 m
2.a.	8 inch	=	203 mm
	60 feet	=	18.2 m
	12 inch	=	0.30 m
2.b.	10 feet	=	3.0 m
	225 psi	=	1.55 MPa
	20 inches of mercury	=	67 kPa

Section 2. None

Section 3.

2.	100 feet	=	30.5 m
	300 gal/min		
=	19 cubic decimetres per second		(dm ³ /s)

Chapter 3.

Section 1. None

Section 2. None

Section 3.

2.a.	100 feet	=	30.5 m
	1/8 inch per foot	=	10.4 millimetres per metre (mm/m)
3.c.	100 feet	=	30.5 m
	4 feet	=	1.2 m

10 feet 6 inches	= 3.2 m
5 feet	= 1.5 m
15 feet	= 4.6 m

Section 4.

2.b. 100 feet	= 30.5 m
15 feet	= 4.6 m
1/8 inch per foot	= 10.4 mm/m
2.c. 2,500 gallons	= 9.5 cubic metres (m ³)
600 gal/min	= 38 dm ³ /s
36 inches	= 0.91 m
50 psi	= 344 kPa
5 psi	= 34 kPa
1,200 gal/min	= 76 dm ³ /s
6,000 gal/min	= 379 dm ³ /s
300 gal/min	= 19 dm ³ /s
3.b. 600 gal/min	= 39 dm ³ /s

Section 5.

2.b. 5,000 gallons	= 19 m ³
2.g. 10 gal/min	= 0.6 dm ³ /s
25 gal/min	= 1.6 dm ³ /s
2.j. 1/8 inch per foot	= 10.4 mm/m

Chapter 4.

Section 1.

4.b. 20,000 gallons	= 76 m
4.g. 1.5 psia	= 10.4 kPa
70° F	= 21° C
50 gal/min	= 3.0 dm ³ /s
10 gal/min	= 0.6 dm ³ /s

4.h.	2 inches	≈ 51 mm
	4 inches	≈ 102 m
	6 inches	= 152 mm
	12 inches	= 0.30 m
	24 inches	= 0.61 m
4.i.	50 gal/min	= 3.0 dm ³ /s
	2 inches	= 51 mm
	100 gal/min	= 6.3 dm ³ /s
	6 inches	= 152 mm
	12 inches	= 0.30 m
	3 feet 6 inches	= 1.1 m
5.	13,500 barrels	= 2 146 m ³
	100,000 barrels	= 15 899 m ³
6.b.	3 feet	= 0.91 m
	40,000 gallons	= 151 m ³
	10 feet	= 3.0 m
	20 feet	= 6.0 m
7.a.	12 feet	= 3.7 m
	10 feet	= 3.0 m
	25 feet	= 7.6 m
	50 feet	= 15.2 m
7.b. (1)	2.5 psi	= 17.2 kPa
	100° F	= 38° C
	100 feet	= 30.5 m

7.b. (2) (Tabulation)

Tank Capacity	Minimum Distance From Property Line or Nearest Important Building
---------------	--

(Cubic Metres)

(Metres)

1.00 or less	0.5
1.01 to 2.80	3.0
2.81 to 45.40	4.6
45.41 to 113.50	6.0
113.51 to 189.30	18.3
189.31 or more	30.5

8.a. 25 feet	= 7.6 m
--------------	---------

100 feet	= 30.5 m
----------	----------

8.b. 25 feet	= 7.6 m
--------------	---------

50 feet	= 15.2 m
---------	----------

8.c. 100 feet	= 30.5 m
---------------	----------

200 feet	= 60.1 m
----------	----------

8.d. 50 feet	= 15.2 m
--------------	----------

Section 2.

1.a. 40,000 gallons	= 151 m ³
---------------------	----------------------

12 feet	= 3.7 m
---------	---------

1,000 gallons	= 3.7 m ³
---------------	----------------------

24 inch	= 0.61 m
---------	----------

1/8 inch	= 3.2 mm
----------	----------

3 inches	= 76 mm
----------	---------

6 inches	= 152 mm
----------	----------

3 feet per second	= 0.91 m/s
-------------------	------------

2 inches in 10 feet	= 50 mm in 3 m
---------------------	----------------

3 feet 6 inches	= 1.1 m
-----------------	---------

6 inches	= 152 mm
12 feet	= 3.7 m
40,000 gallons	= 151 m ³
1.b. 12 feet	= 3.7 m
40,000 gallons	= 151 m
24 inches	= 0.61 m
1/8 inch	= 3.2 mm
3 inches	= 76 mm
3 feet per second	= 0.91 m/s
1 psia	= 6.9 kPa
661 gallons	= 2.5 m ³

Section 3.

1. 40,000 gallons	= 151 m ³
12 feet	= 3.7 m
1.b. 10,000 barrels	= 1 590 m ³
18 inches	= 0.45 m
1.c. 10,000 barrels	= 1 590 m ³
4. 1.5 psi	= 10.4 kPa
70° F	= 21° C
2,500 barrels	= 397 m ³
100,000 barrels	= 15 899 m ³
3/16 inch	= 4.8 mm
24 inch	= 0.61 m

For conversion of Figure 4 see page A-22.

5. 1 foot	= 0.30 m
20 feet	= 6.1 m

6.a.	12 feet per second	=	3.7 m/s
	3 feet per second	=	0.91 m/s
6.b.	4 inches	=	101 mm
	6 inches	=	152 mm
	12 inches	=	0.30 m
	24 inches	=	0.61 m
6.c.	2 inches	=	51 mm
7.a.	30 inch	=	0.76 m
7.b.	30 inch	=	0.76 m
7.f.	18 inches	=	0.45 m
	5 inch	=	127 mm
	0° F	=	(Minus) 18° C
	150° F	=	66° C
	240° F	=	116° C
7.h.	3 inches	=	76 mm

For conversions of Figures 5 through 9 see pages A-23 through A-27.

Section 4.

1.	100,000 barrels	=	15 899 m ³
	10,000 barrels	=	1 590 m ³
3.a.	10 gal/min	=	0.6 dm ³ /s
	2 inches	=	51 mm
	100 gal/min	=	6.3 dm ³ /s
3.b.	6 inches	=	152 mm
3.c.	12 inches	=	0.30 m
	50 gal/min	=	3.0 dm ³ /s

For conversions of Figures 11 and 12 see page A-29 and A-30.

4.b.	12 inches	= 0.30 m
4.e.	1.5 ounces per square inch	= 0.62 kPa
	50 feet	= 15.2 m
	12 feet	= 3.7 m
	15 feet	= 4.6 m
4.h.	1.5 psia	= 10.4 kPa

Section 5.

2.	10,000 barrels	= 1 590 m ³
	15,000 barrels	= 2 385 m ³
	1 foot	= 0.30 m
	6 feet	= 1.8 m
2.a.	5 feet	= 1.5 m
	3 feet	= 0.91 m
	1 foot vertical to 1-1/2 foot horizontal = 1 m vertical to 1-1/2 m horizontal	
	6 inches	= 152 mm
	3 inches	= 76 mm
2.c.	14 inches	= 0.35 m
	6 inches	= 152 mm
	8 inches	= 203 mm
2.d.	50,000 bbl	= 7 949 m ³
3.	1 foot	= 0.30 m

Chapter 5.

Section 1.

1.b.	30 inches	= 0.76 m
1.j.	5,000 barrels	= 795 m ³
1.k.	2 feet	= 0.61 m
1.r.	2 feet	= 0.61 m

Section 2.

2.a. 30 inches	= 0.76 m
4 feet	= 1.2 m
3 feet	= 0.91 m
5,000 barrels	= 195 m ³
2 feet	= 0.61 m
2.b. 50° F	= 10° C
212° F	= 100° C
2.c. 30 inch	= 0.76 m

Section 3. None

Chapter 6.

Section 1.

3.a. 1/8 inch	= 3.2 mm
6 inches	= 152 mm

Chapter 7.

Section 1.

2.a. 300 feet	= 91.4 m
100 feet	= 30.5 m
2,500 gal/min	= 158 dm ³ /s
2.b. 100,000 gallons	= 379 m ³
30° F	= (Minus) 1° C
3. 300 feet	= 91.4 m

Chapter 8.

Section 1. None

Section 2.

1.a. 40,000 gallons	= 151 m ³
1.5 psia	= 10.3 kPa

- | | | | |
|------|----------------|---|-------------------|
| 1.b. | 20,000 gallons | = | 76 m ³ |
| | 1.5 psia | = | 10.3 kPa |
| 1.c. | 1.5 psia | = | 10.3 kPa |

Section 3.

- | | | | |
|----|----------------|---|--------------------|
| 1. | 1,320 gallons | = | 5 m ³ |
| | 660 gallons | = | 2.5 m ³ |
| | 42,000 gallons | = | 159 m ³ |
| | 10,500 gallons | = | 40 m ³ |

Chapter 9.

Section 1.

- | | | | |
|------|---|---|---------|
| 1.b. | 200,000 BTU's per hour = 2 110 MegaJoules per hour (MJ/h) | | |
| 3.a. | 200 psig | = | 1.4 MPa |
| | 100° F | = | 38° C |
| 3.c. | 45° F | = | 7° C |

Section 2.

- | | | | |
|------|----------------|---|-----------------------|
| 3.a. | 30,000 gallons | = | 114 m ³ |
| | 5 psi | = | 34.5 kPa |
| 5.c. | 1 BTU | = | 1.055 kiloJoules (kJ) |
| 5.d. | 1 BTU | = | 1.055 kJ |

Metric Conversion

TABLE 1
Typical Properties of Burner Fuel Oils

Grade No.	1	2	4	5	6
Absolute Density (kg/dm ³)	0.8184	0.8379	0.9198	0.9508	0.9639
Specific Gravity	0.82	0.84	0.92	0.95	0.96
Reid Vapor Pressure	0	0	0	0	0
Minimum Flash Point (°C)	38	38	54	54	66
Viscosity (mm ² /s)	2.71	6.00	53.80	108.00 to 323.8	2 157.60 to 4 315.30
Pour Point (°C)	-23	-20	-18	-7 to -1	-1 to -21
Color	Clear to Straw Color	Straw Color to Amber	Light Brown to Black	Brown to Black	Brown to Black

Metric Conversion

TABLE 2
Fuel Transfer Flow Rates

Service ¹	Diesel Fuel	Jet Fuel	Burner Fuel Oils	Avgas and Mogas
Between super tanker and storage (m ³ /h)	3,800	3,800	3,800	3,800
Between regular tanker and storage (m ³ /h)	1,300	1,300	1,300	1,300
Between barge and storage (m ³ /h)	400	400	400	400
To fleet oilers (m ³ /h)	800	800	500	500
To AOE's	1,600	1,600	500	500
To carriers (m ³ /h)	600	600	-----	400
To average cruisers (m ³ /h)	300	160	-----	-----
To average destroyer (m ³ /h)	300	160	-----	-----
Between storage tanks (dm ³ /s)	40	40	40	40
	to	to	to	to
	600	600	80	80
Tank car unloading to storage (dm ³ /s per car)	20	20	20	20
Tank truck unloading to storage (dm ³ /s per truck)	20	20	20	20
Storage to tank car loading (dm ³ /s per car)	40	40	20	20
			to	to
			40	40
Storage to tank truck loading (dm ³ /s per loading arm or bottom loading hose)	20	20	20	20
	to	to	to	to
	40	40	40	40
Delivery from direct fueling stations to aircraft (dm ³ /s)	-----	40	-----	
Delivery from refueler truck to aircraft (dm ³ /s)	-----	20	-----	

¹At dockside, deliveries from tankers should be assumed to be at a pressure of 550 to 690 kPa, and deliveries to tankers to be at 414 kPa. Rates to other ships are maximums based on fueling at sea capacities. Lesser rates for fueling at piers can be used if more practicable. Loading rates are based on 275 kPa minimum at ship connections.

Metric Conversion

TABLE 3
Minimum Center-to-Center Spacing For Steel Pipe
Welded Steel Pipe With Class 150 ANSI Flanges

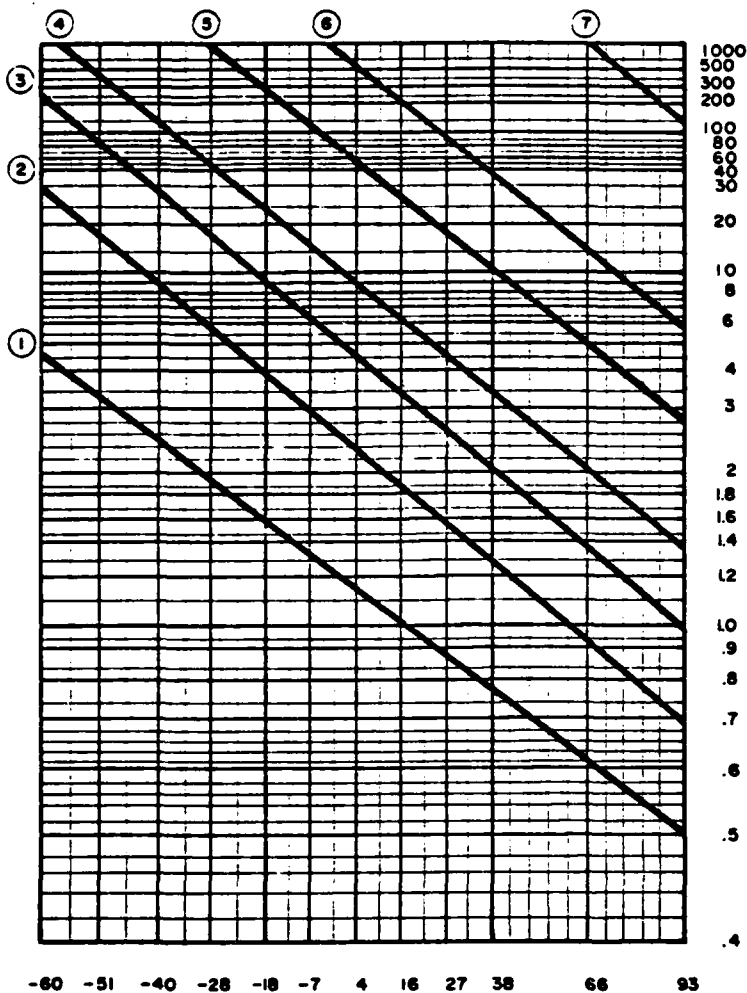
Nominal Pipe Size (Inches)		Flange O.D. (mm)		Spacing (mm)	Nominal Pipe Size (Inches)		Flange O.D. (mm)		Spacing (mm)
A	B	A	B		A	B	A	B	
18	18	635	635	686	10	10	406	406	457
18	16	635	597	667	10	8	406	343	425
18	14	635	533	635	10	6	406	279	394
18	12	635	483	607	10	4	406	229	368
18	10	635	406	572	8	8	343	343	394
18	8	635	343	540	8	6	343	279	362
18	6	635	279	508	8	4	343	229	337
18	4	635	229	254	6	6	279	279	330
16	16	597	597	648	6	4	279	229	305
16	14	597	533	622	4	4	229	229	279
16	12	597	483	591	4	3	229	191	279
16	10	597	406	552	3	3		191	241
16	8	597	343	521					
16	6	597	279	489					
16	4	597	229	464					
14	14	533	533	584					
14	12	533	483	559					
14	10	533	406	521					
14	8	533	343	489					
14	6	533	279	457					
14	4	533	229	432					
12	12	483	483	533					
12	10	483	406	495					
12	8	483	343	464					
12	6	483	279	432					

Metric Conversion

TABLE 4
Pipe Support Spacing
Welded Steel Pipe ASTM A53, Grade B
Maximum Temperature 150° F
No Insulation

Nominal Pipe Size (Inches)	Sched. or Weight	Support Spacing (m)	
		Continuous	End Spans
1/2"	80 (XS)	2.44	1.52
3/4"	80 (XS)	3.05	2.13
1"	80 (XS)	3.96	2.74
1-1/2"	80 (XS)	5.49	3.66
2"	80 (XS)	6.40	4.27
2-1/2"	40 (STD)	6.40	4.27
	80 (XS)	7.62	5.18
3"	40 (STD)	7.01	5.18
4"	40 (STD)	8.23	6.10
6"	40 (STD)	9.75	7.92
8"	30	11.28	9.14
	40 (STD)	12.19	9.75
10"	30	12.19	10.06
	40 (STD)	13.11	10.67
12"	30	13.11	10.67
	(STD)	14.02	11.58
14"	20	13.11	10.67
	30 (STD)	14.63	11.89
16"	20	13.11	11.28
	30 (STD)	14.63	11.89
18"	20	10.67	11.28
	(STD)	15.54	12.50
20"	20 (STD)	14.94	12.50

KINEMATIC VISCOSITY - SQUARE MILLIMETRES PER SECOND (mm²/s)

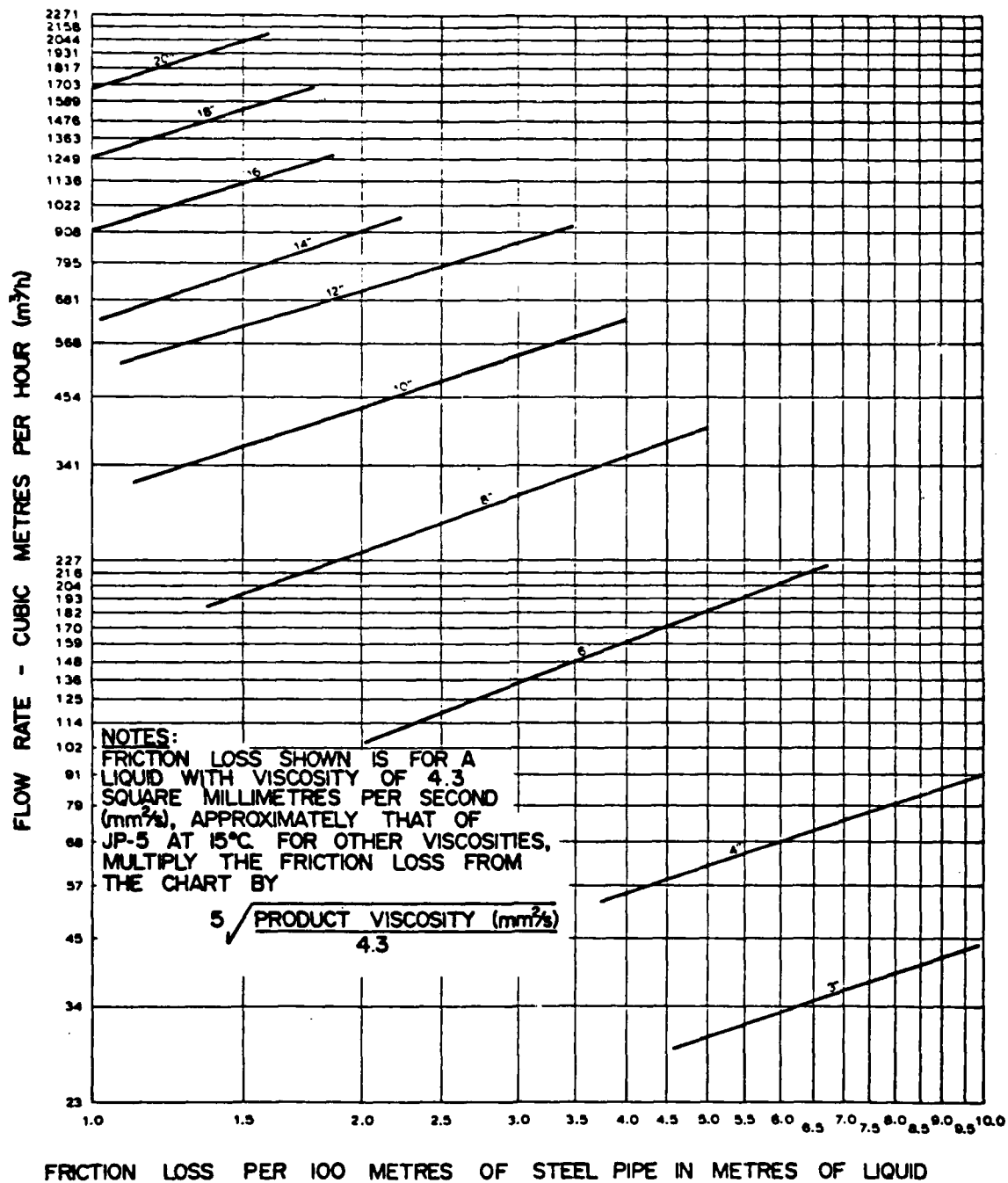


TEMPERATURE °C

- | | |
|--|---|
| ① MIL-F-5572 AVIATION GASOLINE (AVERAGE) | ⑤ MIL-F-16884-DIESEL FUEL MARINE |
| ② MIL-T-5624 (JP-4) FUEL (AVERAGE) | ⑥ VV-F-815 № 5 FUEL OIL (AVERAGE) |
| ③ MIL-T-5624 (JP-5) FUEL (AVERAGE) | ⑦ VV-F-815 № 6 FUEL OIL (SINGLE SAMPLE) |
| ④ VV-F-815 № 2 FUEL OIL (AVERAGE) | |

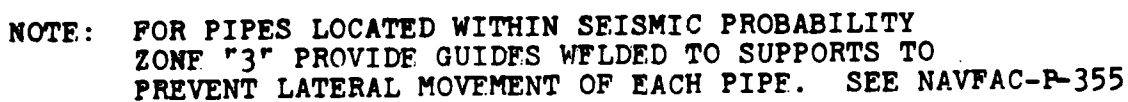
Metric Conversion

FIGURE 1
Petroleum Fuels
Viscosity Vs. Temperature

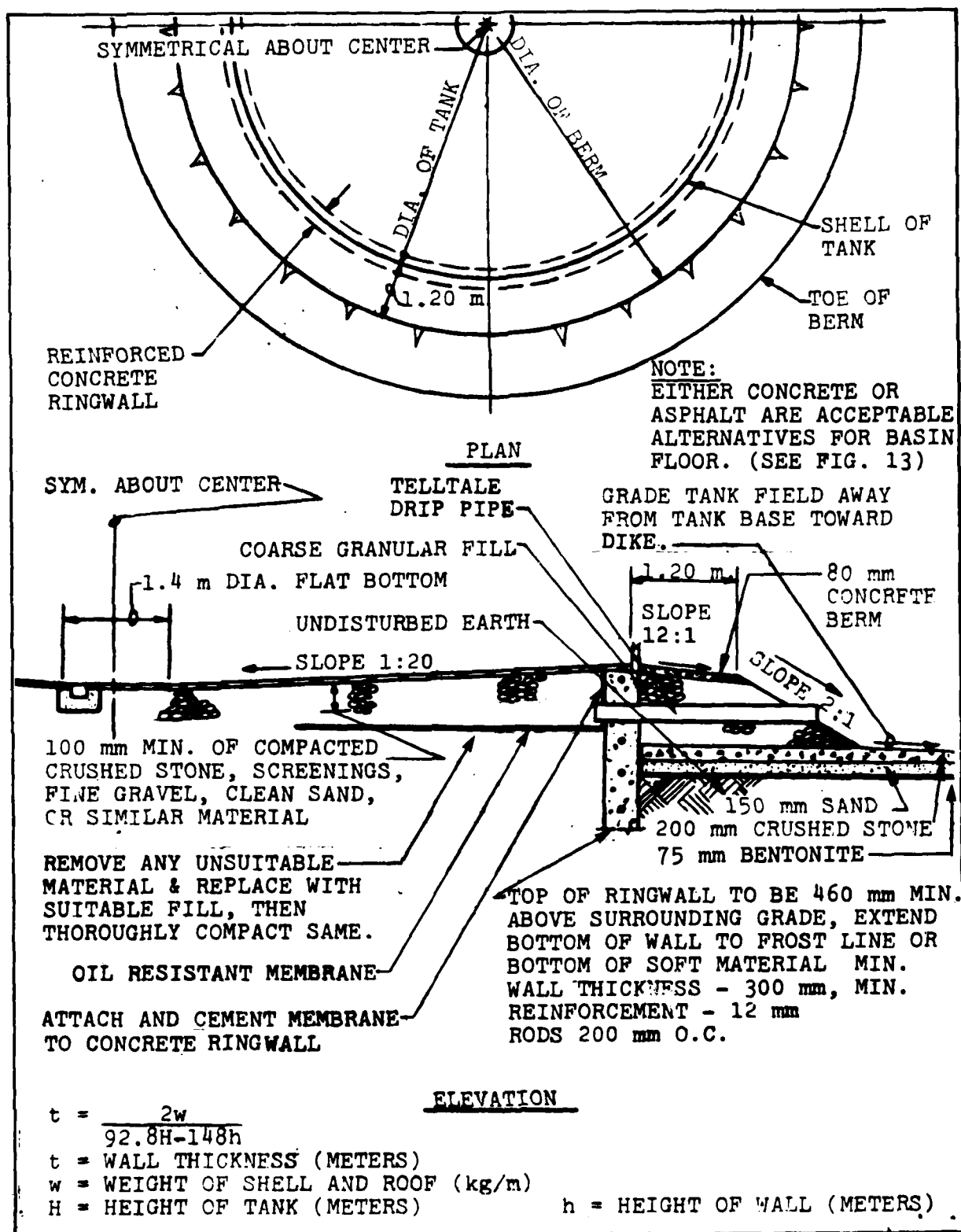


Metric Conversion

FIGURE 2
Pipe Flow Chart

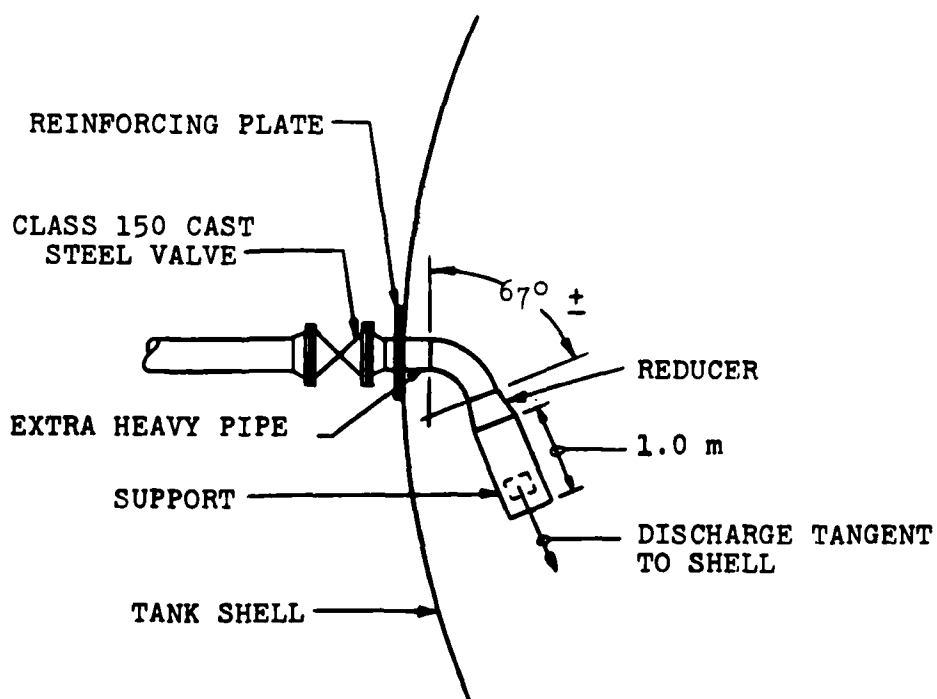


A-21

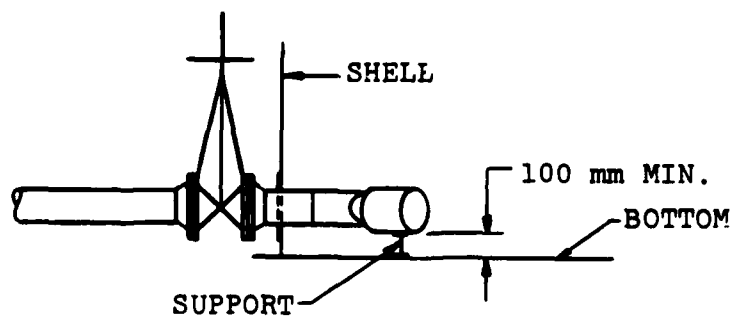


Metric Conversion

FIGURE 4
Ringwall Foundation for Vertical Tanks



PLAN

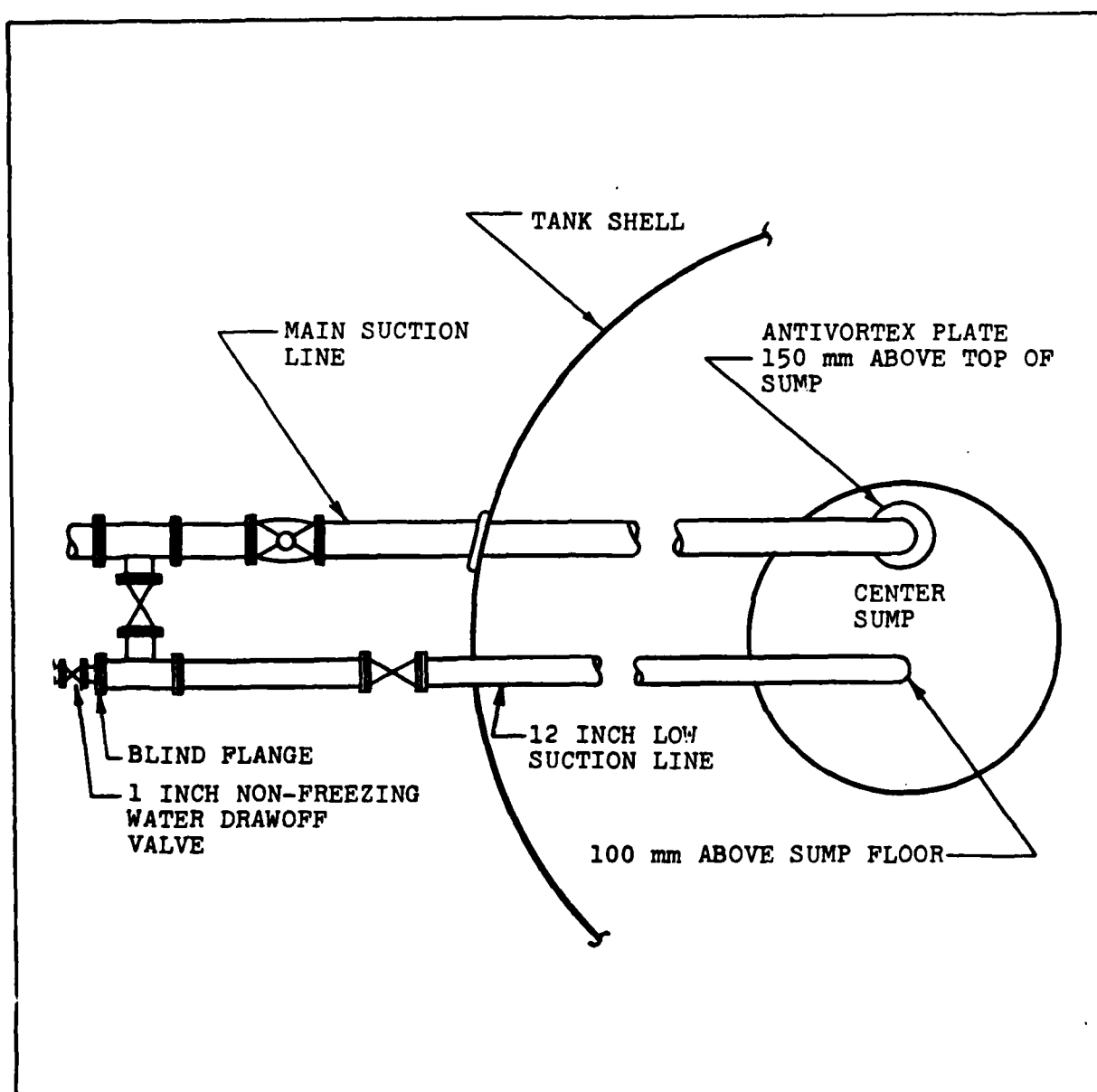


NOTE: MAXIMUM INLET VELOCITY SHALL NOT EXCEED 1.0 m/s UNTIL FILLING CONNECTION IS FULLY SUBMERGED.

Elevation

Metric Conversion

FIGURE 5
Typical Inlet Connection for Vertical Aboveground Storage Tank

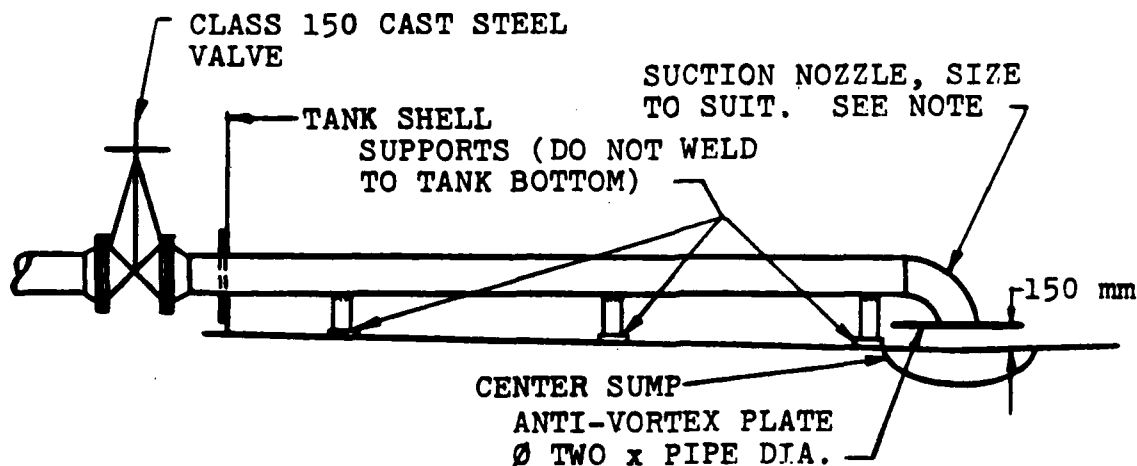


Metric Conversion

FIGURE 6
Transfer Pump Suction Piping for Vertical
Aboveground Circulating Storage Tank
at Aviation Activities
Plan View

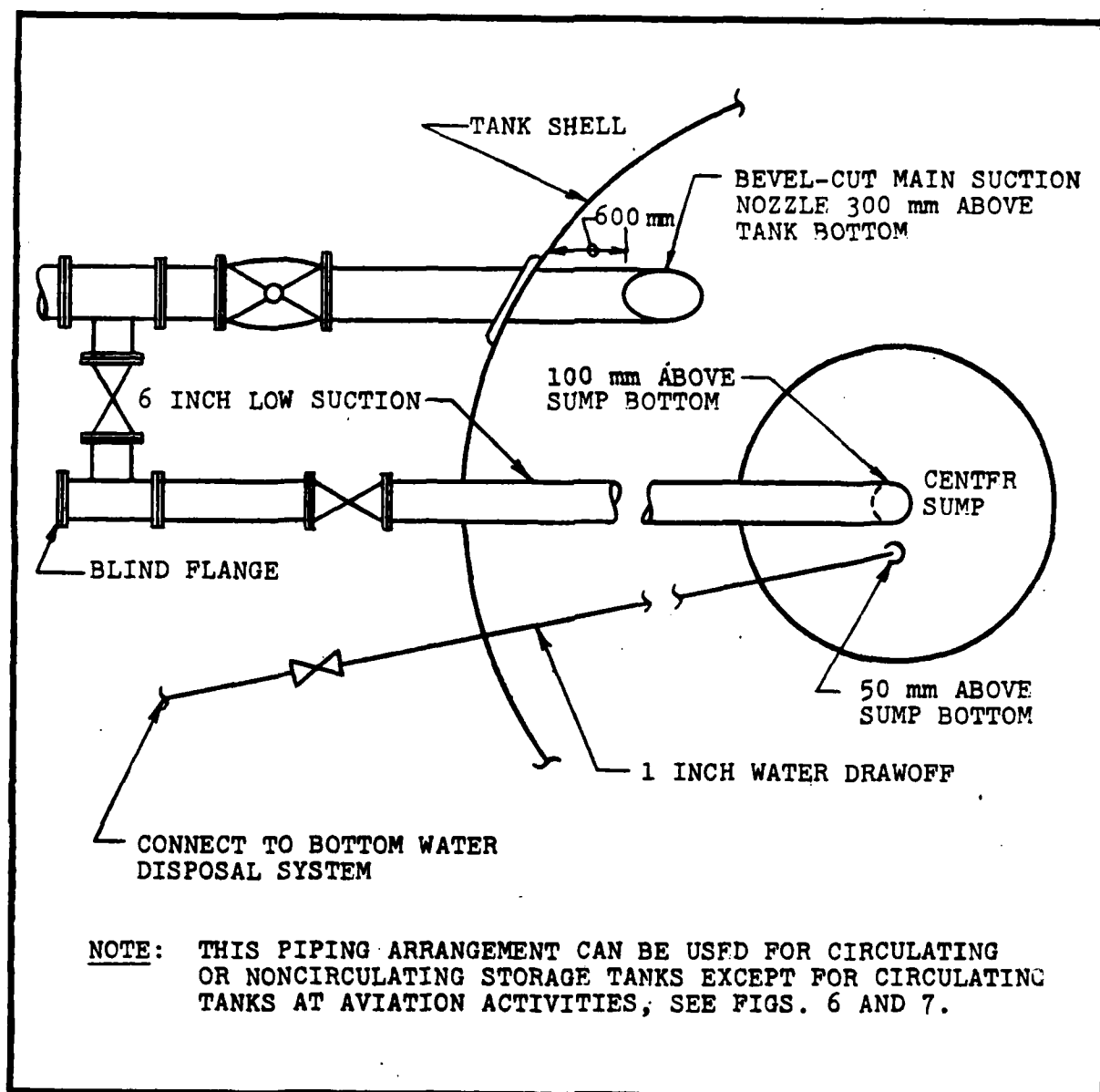
NOTE:

FOR AVIATION FUEL TANKS, AT AVIATION ACTIVITIES, LOCATE SUCTION INLET DIRECTLY ABOVE SUMP. FOR OTHER PRODUCTS IT MAY BE LOCATED AWAY FROM THE SUMP.



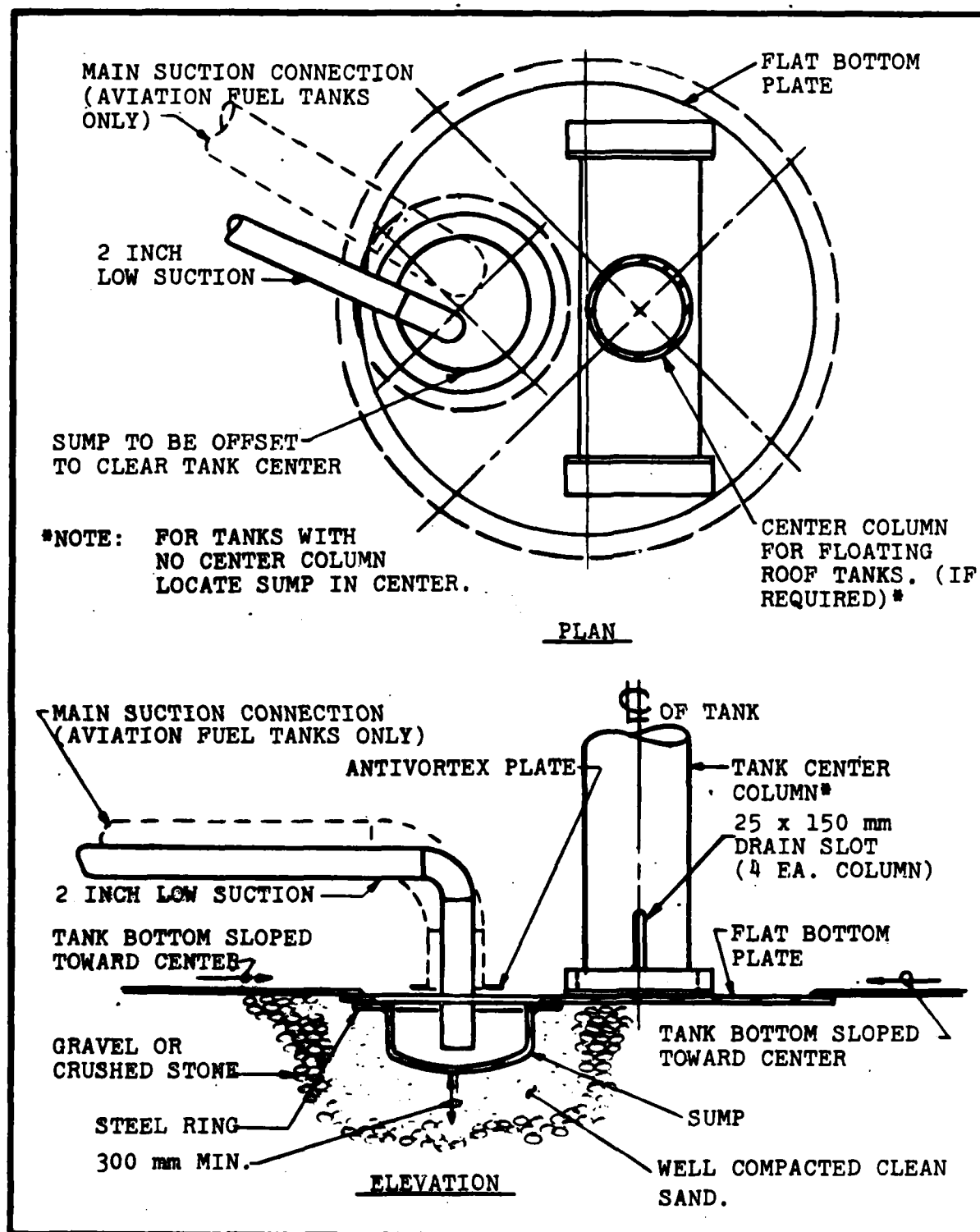
Metric Conversion

FIGURE 7
Transfer Pump Suction Piping for
Vertical Aboveground Circulating Storage Tank
Elevation



Metric Conversion

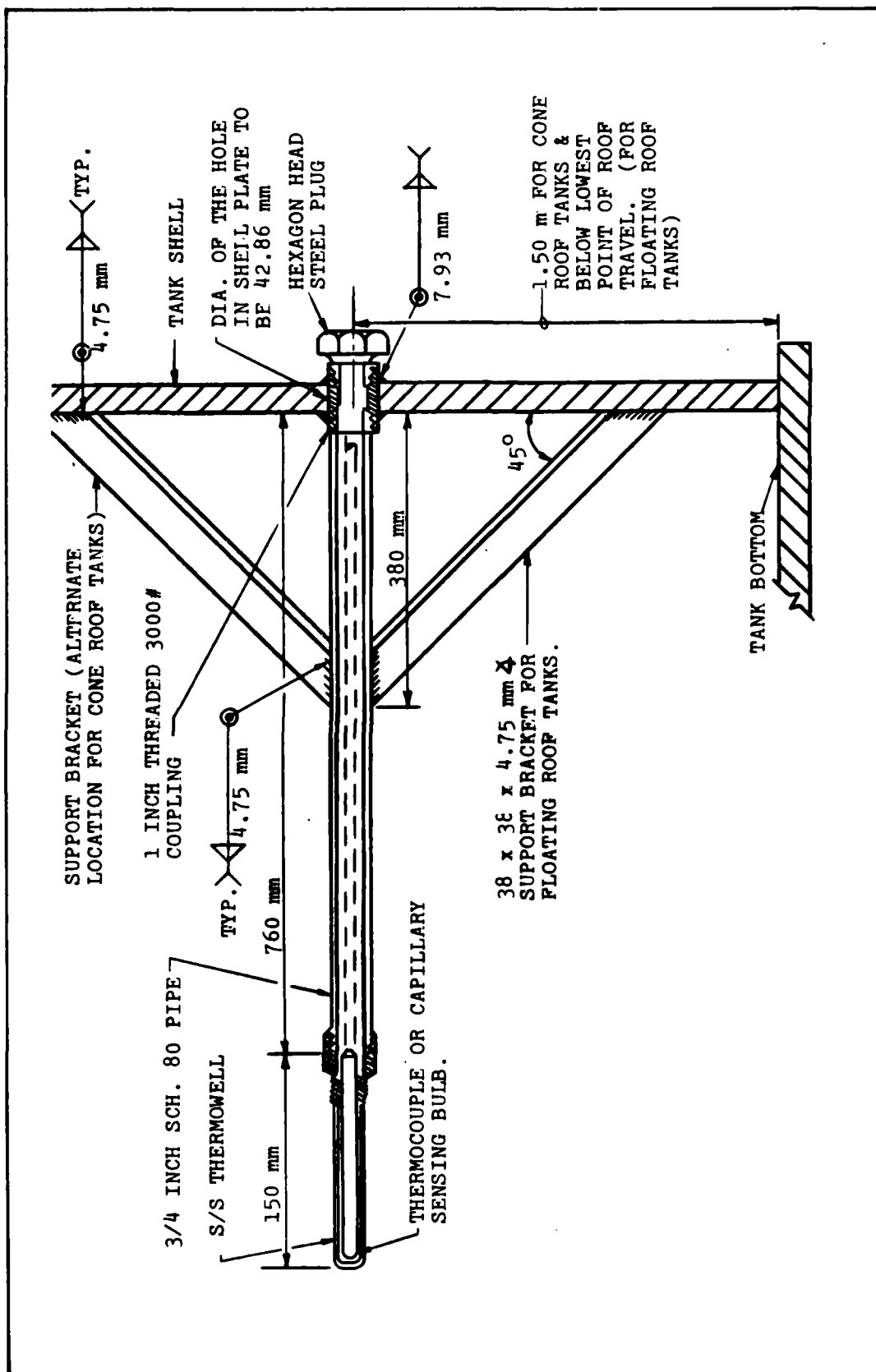
FIGURE 8
Transfer Pump Suction Piping for
Vertical Aboveground Storage Tank



Metric Conversion

FIGURE 9

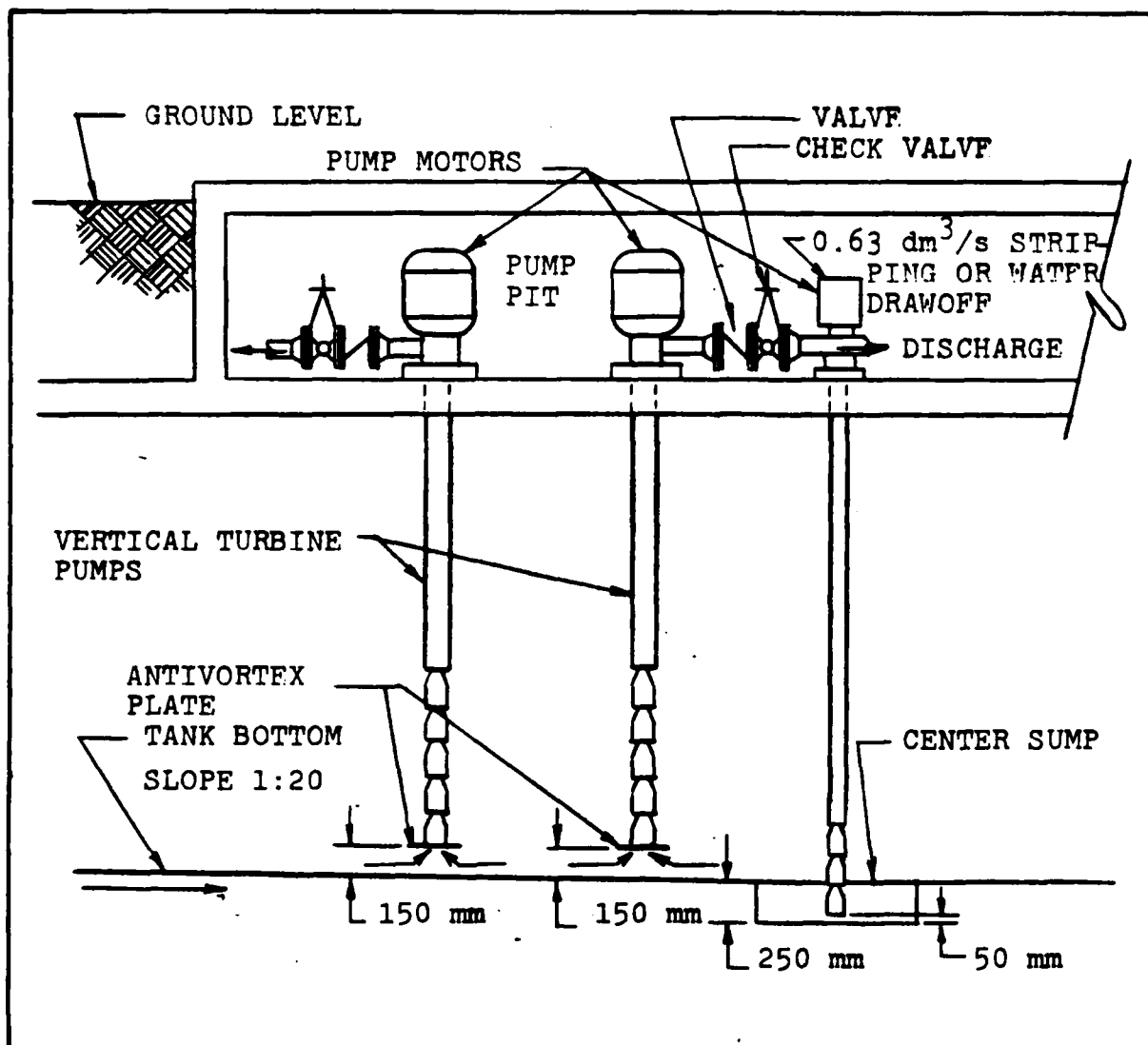
Center Drain Sump for Vertical Aboveground Circulating Storage Tank



Metric Conversion

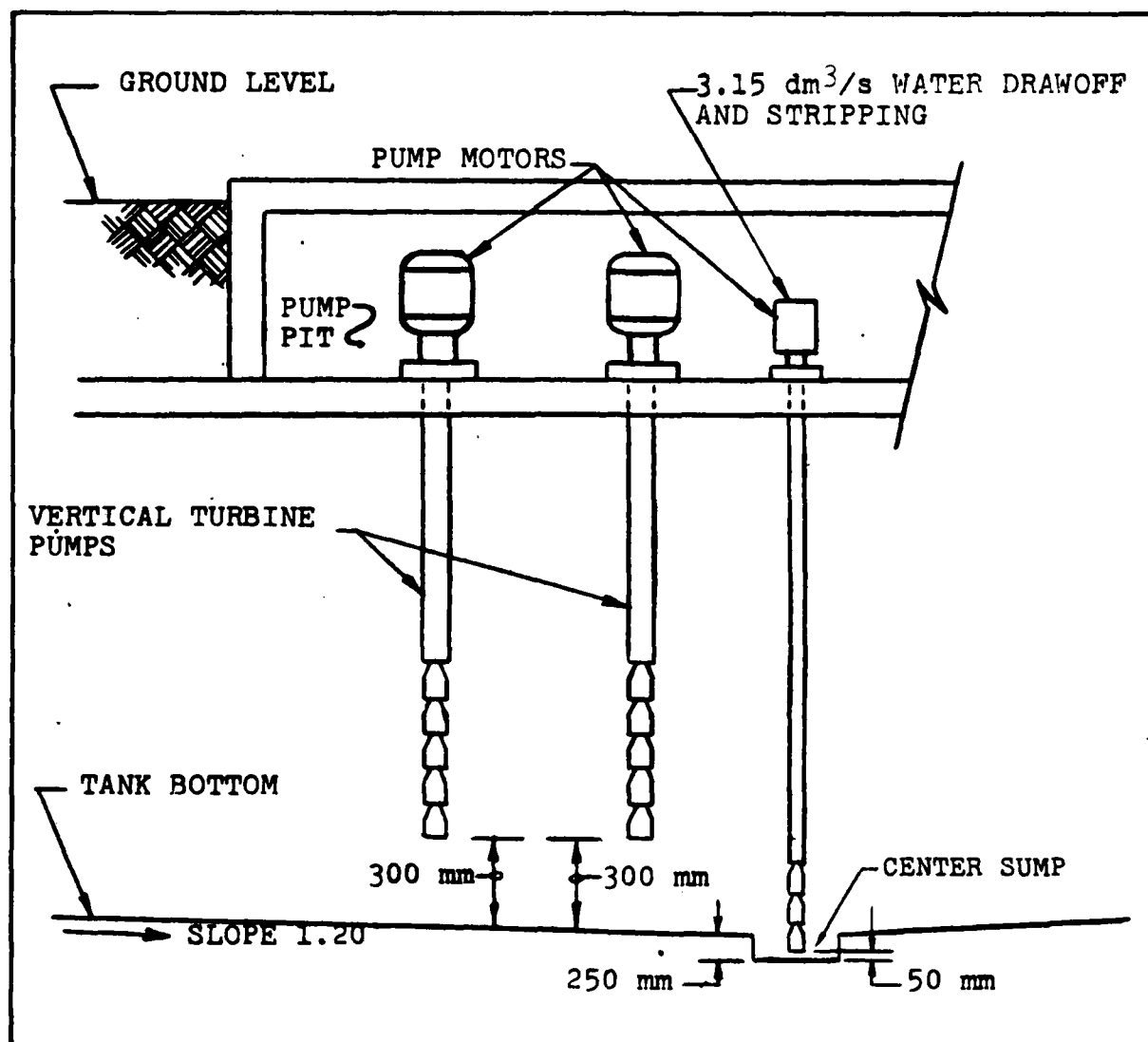
FIGURE 10

Typical Storage Tank Thermometer Well



Metric Conversion

FIGURE 11
Transfer Pump Arrangement for
Vertical Underground Circulating Storage Tank
Elevation

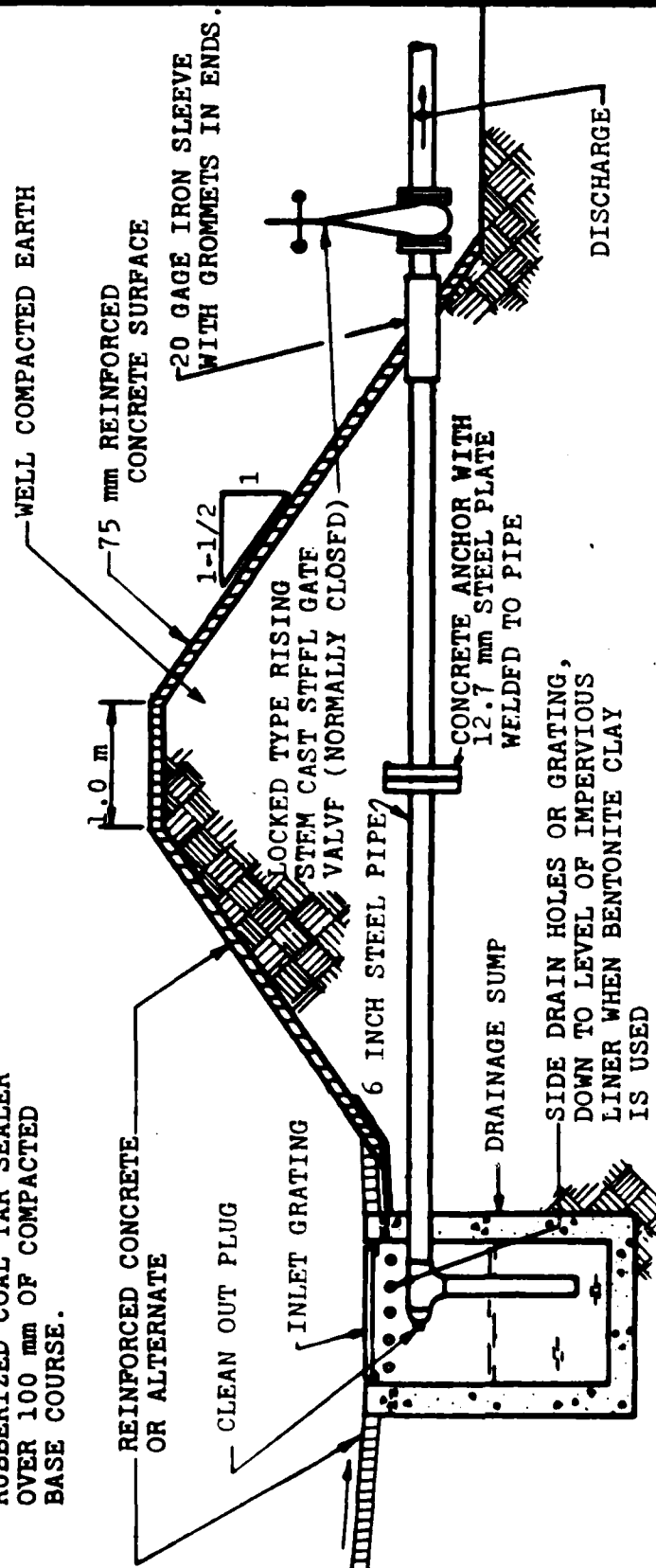


Metric Conversion

FIGURE 12
Transfer Pump Arrangement for
Vertical Underground Non-Circulating Storage Tank

ALTERNATE METHODS:

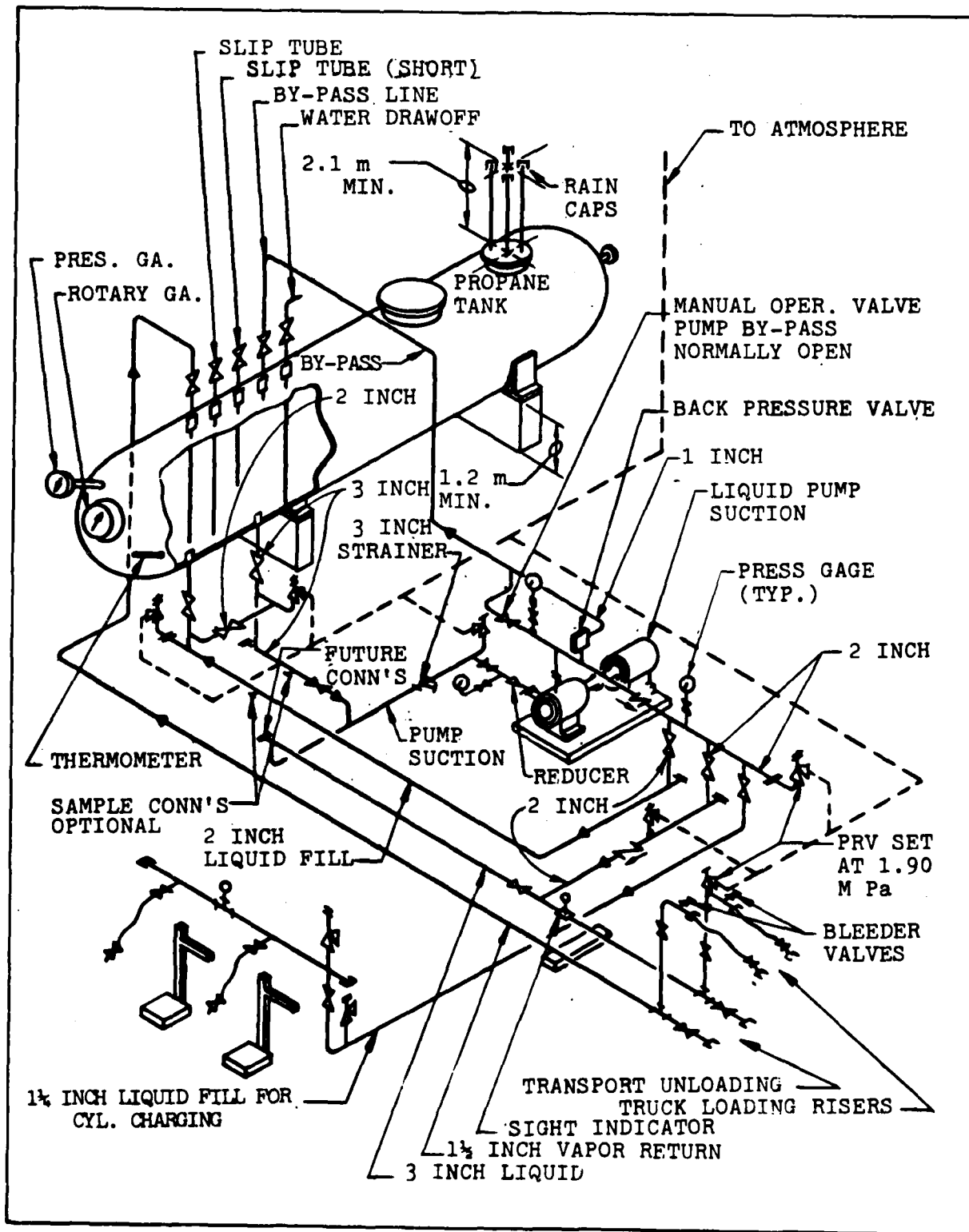
1. 75 mm LAYER OF BENTONITE TYPE CLAY COVERED BY 155 mm OF SAND AND 200 mm OF CRUSHED STONE
2. 50 mm LAYER OF ASPHALT W/ RUBBERIZED COAL TAR SEALER OVER 100 mm OF COMPACTED BASE COURSE.



Metric Conversion

FIGURE 13

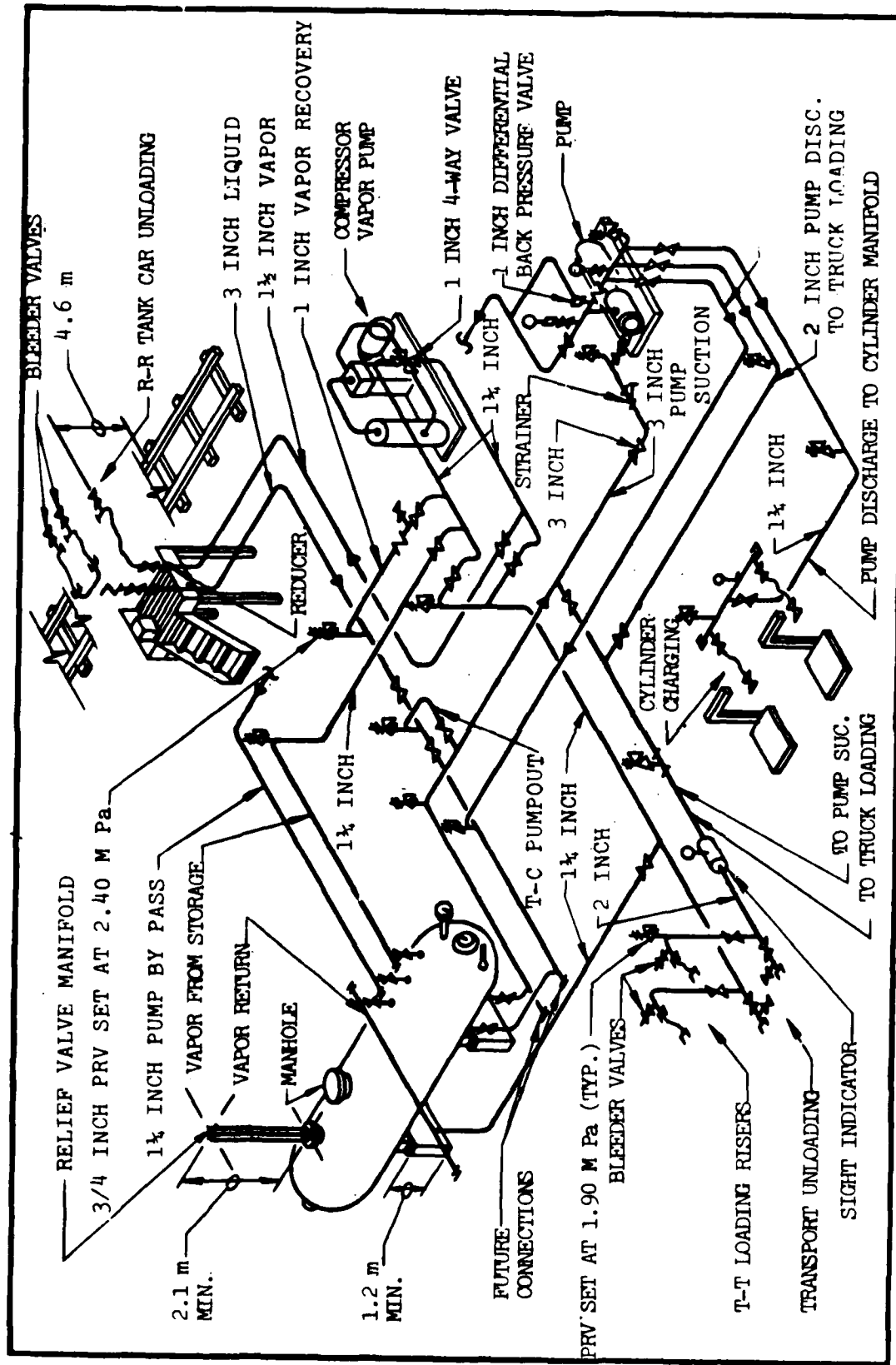
Typical Earth Dike with Drain



Metric Conversion

FIGURE 14

Typical Small Volume LPG Facility for Trucks and Cylinders



Metric Conversion

FIGURE 15

Typical LPG Vapor Compression System for Tank Cars or Water Borne Deliveries

END

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